THURSDAY, JUNE 12, 1884

BRITISH MITES

The British Oribatidæ. By A. D. Michael. (Ray Society, 1884.)

WE congratulate the Ray Society on this valuable addition to their excellent series of monographs. Mr. Michael indeed modestly asks us to "kindly remember that this book is the record of work done in the scanty leisure of a very busy man," but though this may add to our gratitude, and serve as an encouragement to others, no one, we think, after reading the book will feel that any excuse or apology was needed. When Mr. Michael commenced his study of this curious family of mites scarcely any species were recorded as British, there were very few of which the whole life-history was known, and Nicolet's was the only work dealing with the anatomy of the family.

Mites are not perhaps a very attractive group, nevertheless many species are extremely curious and some very pretty, as a glance at Mr. Michael's excellent figures is sufficient to show, especially those of *Tegeocranus latus*, *Leiosoma palmicinctum*, and *Cepheus ocellatus;* possibly indeed, says Mr. Michael, "no more bizarre or remarkable creatures exist than these, when nearly fully grown, and bearing on their backs, ring within ring, concentric circles or ovals of these curious and disproportionately large line-of-beauty shaped spines formed of clear, colourless chitin, and strongly serrated in the first species, and of the beautiful and iridescent membranous fans in the two latter."

Some, he adds, especially "of the immature stages are amongst the most beautiful creatures of the order; and only those who are not acquainted with the Acarina can suppose that none are beautiful. It is needless to say that the Oribatidæ are highly interesting and instructive, because the same thing may be said of every family of created beings; no one can devote himself to the study of any class of organism without becoming from day to day more deeply impressed with the admirable manner in which its members are adapted to their wants, and the marvellous way in which the different parts are varied in different species, so as to provide more efficiently for their protection and continuance. This fact of having constantly before his eyes the wonders of the individual family or order which he is investigating is apt to cause the specialist to forget for the time that there are hundreds of other families equally interesting, beautiful, and wonderful in their construction and life-histories. It is only by endeavouring to base his special knowledge upon the wider foundation of general interest in the works of nature that the naturalist escapes this error, and appreciates the harmony between the particular class and other equally glorious types of life. Endeavouring to bear all this in mind, I feel that I am not justified in saying that the Oribatidæ have any claim on the biologist beyond that of any of the endless varieties of other forms of animals; but I do say that they have an equal claim; and I think I may confidently assert that any observer who inquires into the complex structure of these minute creatures, their singular life-histories, or the quaint and somewhat exceptional habits of some of the species, will rise from his task fully rewarded for the time that he has spent."

The work is divided into two parts: in the first the author gives an account of the terminology, literature, classification, development, habits, methods of collection and preparation, and anatomy; while the second is devoted to descriptions of the genera and species.

The principal home of the Oribatidæ is in moss of various sorts, on lichens, and in fungi; others live in dead wood, many are found in the debris under furze bushes, in the needles of which the nymphs burrow. Pelops, Hoplophora, and others are found among the fallen leaves of Scotch pines; some frequent other trees, while *Oribata sphagni* and *Notaspis lacustris* are aquatic. The whole family with one doubtful exception are vegetable feeders; and, being without any weapons of offence, are all the more in need of defensive arrangements, with which indeed they are liberally provided. Their carapace is thick, with in many cases curious provisions for the protection of the legs, and they most of them have the habit of shamming dead.

Mr. Michael differs from the account given by Nicolet of the internal anatomy in several important respects, and considers that the conspicuous organs, usually called stigmata, are really organs of sense, probably of hearing or smell, and he says, "I incline to the former."

The life-history falls into four well-marked periods—the egg, larva, nymph, and imago. Dujardin indeed asserted that the Oribatidæ are viviparous, and the statement has been repeated in various standard books, but as a general rule the reverse is the case. The egg is generally elliptical, or cylindrical with rounded ends. In some cases it absorbs moisture, and the exterior membrane, being hard and brittle, splits longitudinally and allows the inner or vitelline membrane to be seen through the opening. This constitutes the stage called by Claparède the "Deutovum."

The larva is invariably hexapod, and all six legs are monodactyle, tridactyle tarsi being confined to the imagos. The larval stage is comparatively short, generally lasting from three weeks to two or three months. Mr. Michael does not consider that the larva undergoes any change of skin until it passes into the nymph.

The nymph "may be defined as the creature after it has become octopod," but before the first month. It is the principal period of growth and occupies a considerable proportion of the lifetime; "it is also the time of gay colouring and of beauty." "When the nymph is fully fed, and is about to become an imago, it creeps into a hole, or some other sheltered position, stretches out its legs, fixing its large monodactyle claws firmly into the substance it is resting on, and then gradually becomes inert, perfectly motionless, and to all appearance dead; it ceases to feed, and does not exhibit any sign of life if touched or injured."

Mr. Michael coincides with the opinion of Claparède and Mégnin that during this period there is an entire reorganisation of the internal structures, and "the different parts of the body of the adult are formed, not at the expense of the same parts of the nymphs, but from the general body substance."

Till Mr. Michael traced the life-histories of these creatures, the immature stages of eight species only were known to us. Nicolet, indeed, gives eleven, but as to three he is, in Mr. Michael's opinion, certainly in error. In all other species the life-history when known has been traced by Mr. Michael himself.

In breeding Mr. Michael used glass cells "composed of ordinary microscopical glass slips 3×1 inch, having in the centre, fastened by marine glue or Canada balsam, a glass ring made of a transverse slice of glass tubing about $\frac{3}{4}$ or $\frac{7}{8}$ inch in diameter, the length of the tube, and consequently the depth of the cells, being usually about $\frac{3}{8}$ inch. The tubing I employ is of tolerably thin glass, if very thick it is opaque, and leaves little room inside the cell. Over this a thin glass cover, rather larger than the diameter of the tubing, was laid, either a circle or a square; the latter is often handy, as the projecting corners are convenient to take it on or off by, or sometimes a second slide or a broken piece of one is more serviceable. This cover was always quite loose, and simply held on by an ordinary brass-wire microscopical spring-clip; of course the upper edge of the slice of glass tube required to be smooth, so that the cover would lie flat upon it, and not allow the minute prisoners to escape. A cell so prepared was carefully cleaned out, and examined under the microscope, to see that it did not contain Acarina or ova. A small piece of thick white blotting-paper, not large enough to cover the whole bottom of the cell, was then placed in it and damped; a piece or two of growing moss or fungus was then placed in the cell, having first been carefully examined under the microscope to see that it also was free from Acarina and ova, and the cell was then ready for use. One or two specimens of the larva, nymph, or species to be observed, were placed in the cell, never so many but what I knew each individual specimen; the cover was put on, fixed with the clip; a label with a statement of what was inside affixed to the slip, and the whole put away in the dark or very dull light."

Another good mode of providing the fungus-eating species with food Mr. Michael found to be by putting a minute piece of mouldy cheese in the cell; this soon bore a fine crop, which was highly appreciated. He found these simple cells answer better than any more elaborate apparatus. Mr. Macintyre's ingenious cork cells, so useful for many small insects, are not suitable for Oribatidæ, in the first place because many are wood-borers, and even those which are not often get lost in the interspaces of the cork. He also found that these cells got dry more rapidly.

He tells us indeed (and having had some experience in similar observations I doubt not that it is so) that no portion of his work has been either more laborious or more interesting than that of tracing the life-histories of the different species through their immature stages. The creatures are minute, scarcely visible indeed to the naked eye, they avoid the light and always endeavour to hide themselves, and yet they must be frequently examined to see what is going on. They must not be touched with any hard instrument, and lastly their transformations last for many months, sometimes for more than a year.

It is obvious indeed that his observations required great and constant care. The hygrometric condition of the cell required continued watching, since if it were made too damp or allowed to get too dry, even for an hour, the labour of months would be lost. Mr. Michael carried his mites about with him on any journey, but it is obvious that alone he would have been wholly unable to devote sufficient time to the care of them, and it was, he tells us, mainly to his wife's patient attention and skilled fingers that his success in rearing them was due. To Mrs. Michael then, as well as to her husband, we will tender our warm thanks and congratulations on this excellent contribution to the natural history of the British Isles.

JOHN LUBBOCK

INJURIOUS INSECTS

Reports of Observations of Injurious Insects and Common Crop Pests during the Year 1883; *with Methods of Preservation and Remedy.* By Eleanor A. Ormerod, F.R.Met.Soc., &c. Pp. 1-80 and 1-16. (London: Simpkin, Marshall, and Co., 1884.)

WE have to congratulate Miss Ormerod on having again produced an excellent summary of the evil doings of injurious insects in this country during the past year. It is full of interesting and useful information, from personal observation, and from the reports sent in by the staff of assistants she has enlisted into her service. Regarded from a popular point of view these annual Reports do great service by explaining to those interested the real nature of their insect foes; from a scientific point of view they may do good service by stimulating inquiry, and occasionally bringing to light the hitherto unknown life-histories of certain species; and they should do paramount service from an economical point of view. This latter is really the most important of all, and the item of *expense* in application of remedies is always a serious consideration. With some crops it may sometimes be doubtful if the outlay would be sufficiently recouped; with others (hops for example) the case is different. In that year of hop-famine, 1882, we heard of one grower who expended 15*l.* an acre on washing, and was amply and abundantly repaid, but if all had done the same his profit would have been much less, though the general advantage would have been much greater: possibly in his case his gardens were comparatively isolated, and not subject to migrations from those of less careful neighbours. While on this point we observe that Miss Ormerod is inclined to believe in the supposed migration of the hop-aphis from plum to hop. The habit of migration in *Aphides* from one plant to another totally different is most strongly asserted by Lichtenstein, and almost as strongly pooh-poohed by others. At present we incline to the side of the observant French *savant*, because he states results from actual observation and experiment, whereas his opponents simply deny the possibility.

On one point we do not think Miss Ormerod has proved her case. She inclines to the belief that Myriopods ("False wire-worms" as she terms them) *are* "pests," and do devour healthy vegetable growth; nothing is impossible, but more proof than that given will be required in order to convince those who hold a contrary opinion.

That much vexed sparrow question is touched upon, not in a manner favourable to the sparrow. It is really a vexed question, and we fear will remain so. In the

writer's garden the sparrows are at this moment doing their best to clear the rose-trees of the "green-fly" that infest them, and there can be no doubt that at this season the sparrow is almost entirely insectivorous; at other seasons it is almost equally granivorous; possibly a judicious thinning of sparrows may be salutary, but those who advocate wholesale slaughter should bear in mind the results of the indiscriminate destruction of raptorial birds in these islands.

Miss Ormerod is not always happy in her nomenclature. Excepting in one book there is no such thing known as "*Hybernia prosapiaria*" (p. 5), the specific appellation rightly belonging to an entirely different insect; moreover had she consulted any recent work or list on *Micro-Lepidoptera* she would not have penned the footnote that appears at p. 67.

The illustrations (even if most of them be old and familiar) are good, and add to the usefulness of the Report.

In future Reports we think it deserves Miss Ormerod's consideration whether a meteorological summary in tabular form would not prove a useful addition, compiled especially with regard to the comparative abundance or scarcity of particular injurious species in former years, in connection with the temperature and rainfall in every month of each year. R. McL.

OUR BOOK SHELF

An Elementary Treatise on the Integral Calculus, containing Applications to Plane Curves and Surfaces; with Numerous Examples. By B. Williamson, F.R.S. (London: Longmans, 1884.)

A WORK by Mr. Williamson is like good wine, and needs no commendation from us. We note that this has reached a fourth edition, but Mr. Williamson does not rest content with what he has already achieved. He has given a touch here, brought out into greater prominence a feature there, and not only so, but he has at last added a new detail in the shape of a chapter on multiple integration. In our notices of former editions we have drawn attention to the absence of such a chapter, and we are glad to see that he has at last introduced what he hopes "will be found a useful addition to the book." We need only remark further that this edition has 393 pages against 375 pages in the third edition.

An Elementary Treatise on Solid Geometry. By Charles Smith, M.A. (London: Macmillan and Co., 1884.)

MR. SMITH has already won his spurs as a mathematical writer by his admirable "Conics." This work, as far as possible, is on the same lines. It is not intended to supersede the classic treatises by Salmon and Frost any more than his former book was to take the place of the splendid work on "Conics" by the former of the above-named writers. A feature in Mr. Smith's treatment of the subject is the early discussion of the different surfaces which can be represented by the general equation of the second degree; and in the way in which these surfaces are here handled we think the student will be much interested. The discussion is full and very clear. An excellent collection of exercises adds much to the value of the book for students: those in the body of the chapters being well fitted to bring the text home to the reader. For the majority of students we should say, "Read Smith's 'Solid Geometry,' and you will not need any other work." Those who wish to penetrate into the inmost recesses will find that they have been helped by the study of this work to attack the masterpieces referred to at the outset of our notice.

A Collection of Examples on the Analytic Geometry of Plane Conics; to which are added some Examples on Sphero-Conics. By R. A. Roberts, M.A. (Dublin University Press Series, 1884.)

WE had the pleasure of noticing with commendation (NATURE, vol. xxvi. p. 197) a previous collection of examples by Mr. Roberts on conics and some of the higher plane curves. This has all the merits of the former work, with, we fancy, increased power and skill in the methods employed. A portion of the exercises is common to both works. Much space is devoted to the discussion of properties of circles connected with a conic, especially of circles having double contact with the curve. Great use is here made, and effectively, of elliptic coordinates. "This method simplifies greatly the study of relations involving the angles of intersection of such systems," *i.e.* as have double contact with two fixed confocal conics, "whose differential equations take a simple form." In all there are fifteen chapters, the last of which treats of sphero-conics; in this chapter also much use is made of elliptic coordinates. The collection is likely to be very serviceable to junior students, and will be convenient for reference generally. After perusal we have not detected, we believe, any errata that will cause such students as can use the book with profit any trouble.

Mineralogy. Vol. II. Systematic and Descriptive. By J. H. Collins, F.G.S. (Collins's Advanced Science Series.) (London and Glasgow: W. Collins, Sons, and Co., 1883.)

THIS little book is not, neither does it profess to be, more than a dictionary of minerals. The names, localities, and general characters are given as briefly as possible; and the work seems to be brought up to latest date.

The only point in which the author lays claim to originality of treatment is the classification, and it is precisely here that exception may be taken to the book, with its system of Pyritoids, Spathoids, Haloids, Plethoids, Brithoids, &c., and partial neglect of isomorphous groups. Cerussite, for example, is grouped with phosgenite instead of with aragonite, witherite, &c.

There are a number of crystal figures, but the notations, where used, are not consistent; and in one case, where the cleavages of barytes are wrongly described, the notation is meaningless.

There are several typographical and other errors which should be corrected in a second edition—*e.g.* "Senaviza" (p. 61) should be "Serravezza"; feather-ore (p. 60) should be referred to jamesonite, and not to berthierite; "eulitite" (p. 239) should be "eulytite."

It can scarcely be expected that the book will be much used by the "practical miners, quarrymen, and field-geologists" for whom it is intended. The other readers for whom the author writes, "students of the science classes," may however find it a useful and compendious book of reference, as containing a very complete list of minerals.

Handbook of Vertebrate Dissection. Part III. "How to Dissect a Rodent." By H. Newell Martin, D.Sc., M.D., M.A., and William A. Moale, M.D. (New York: Macmillan and Co., 1884.)

IN the third of their series of Handbooks of Vertebrate Dissection, Drs. Martin and Moale describe a mammal, taking as a type the common rat.

In spite of the authors' remark in the preface that "he who aspires to become a comparative anatomist, and yet finds a rat too small for the observation of all the main facts in its structure, has mistaken his vocation," we think that, for beginners, a larger mammal would have been preferable—at any rate for those who do not aspire to

become comparative anatomists, but only wish to gain a little knowledge of Vertebrate anatomy. It is not an easy matter, for instance, for a beginner to dissect out the nerves of the head and neck in so small a mammal as the rat, and even the less delicate dissections can be done much more satisfactorily on a larger animal.

The directions for examination and dissection are clear, but scarcely full enough in some places. The methods given as regards the vascular system, for instance, are somewhat meagre, and the muscles are not touched upon at all. The woodcuts, which illustrate the skull only, are rough, and we fail to see much advantage in giving figures of the skull when the soft parts—illustrations of which are so much more required by the student—are neglected.

It would perhaps have been as well to omit the question as to the homology of the malleus and incus, given on the first page, as recent researches seem to throw so much doubt on this point.

Apart from the defects to which we have called attention, the book is well arranged, and any one wishing to learn from it how to dissect a Rodent will be greatly helped by its systematic directions and accurate descriptions.

A Course of Instruction in Zootomy (Vertebrata). By T. Jeffrey Parker, B.Sc., Professor of Biology in the University of Otago. (London: Macmillan and Co., 1884.)

ALTHOUGH the study of biology has advanced very rapidly of late years, there is still a great want of really good text-books in several of its branches. The volume before us, which forms the latest addition to the excellent series of "Manuals for Students," is an attempt to fill up one of the most patent of these gaps, and teachers and students of morphology have alike reason to be grateful to Prof. Parker for the manner in which he has performed his work.

The book consists of a short introduction on the methods of dissection, injection, and preservation of specimens, followed by a series of descriptions of certain typical Vertebrates, with practical directions for their examination by dissection or otherwise. The types described are the lamprey, skate, cod, lizard, pigeon, and rabbit, and have been chosen partly from their intrinsic importance, and partly because they "are mostly such as can be readily obtained at any time of year."

The selection of animals is a judicious one, though we should like to have seen Amphioxus included in the list; the descriptions are clear and accurate, and the practical directions good. The book is of convenient size, well printed, and admirably illustrated by a series of upwards of seventy figures, which, with very few exceptions, are original. Many of these figures, notably those of the lamprey and those of the nervous and vascular systems throughout the book, are of unusual excellence, and both author and publishers deserve much credit for having so fully recognised the necessity of providing new illustrations in place of the old worn-out and often incorrect ones that have disgraced our zoological books for so many years. A few of the figures might with advantage be rather larger and more diagrammatic.

While freely and gratefully acknowledging the merits of the book, which are such as to insure its adoption at once in all morphological laboratories, there are certain features which we think should not escape criticism. Thus the general arrangement of the book might easily be improved: the "indented" paragraphs will certainly be taken for minor rather than major subdivisions; the system of numbering the paragraphs does not appear to us to serve any useful end, and the repetition of the title of the book on every alternate page is simply throwing away a valuable opportunity of facilitating reference.

A far more serious objection, however, is the very small allowance of that "salt of morphological ideas" which Prof. Parker extols in his preface but almost entirely omits to supply us with in the book itself. Thus, although the several types selected are arranged in a progressive series, there is practically no attempt made to compare them with one another, or to direct the student's attention to the modifications undergone by the various organs in advancing from generalised to more specialised types. Again, it is surely a mistake to describe the bones of the skull one by one, without any reference to their positions as regards the morphological elements of which the skull consists, or even the distinction between cartilage bones and membrane bones; and the same objection applies with especial force to the description of the urinary organs.

However, in thus criticising what appears to us its weak side, we are fully aware that we are finding fault with the conceptions which Prof. Parker has had of the type of book wanted rather than with the manner in which he has carried out his own ideas on the subject. As a practical laboratory guide, the "Course of Instruction in Zootomy" is a valuable addition to zoological literature, and one which will certainly meet with ready and large acceptance. A. M. M.

Van Nostrand's Science Series. Dynamic Electricity. By J. Hopkinson, J. N. Shoolbred, and R. E. Day (New York: Van Nostrand, 1884.)

Dynamo-Electric Machinery. By Prof. Silvanus P. Thompson. (New York: Van Nostrand, 1884.)

THESE latest additions to Van Nostrand's "Science Series" are reprints of pamphlets published in England. The first of the volumes contains a lecture by Dr. Hopkinson, which originally formed one of a series delivered at the Institution of Civil Engineers a year ago; a paper by Mr. Shoolbred, also delivered last year and a little work on electric calculations, drawn up by Mr. Day for the evening science classes at King's College, published in 1882 by Messrs. Macmillan and Co. For the title "Dynamic-Electricity," the American publishers of this medley are alone responsible. The other volume is a reprint of Prof. Thompson's Cantor Lectures, with an introduction by Mr. F. L. Pope. Mr. Pope's idea of editing appears to be to reprint baldly from the unrevised English issue, and to foist into the book two or three large unexplained diagrams of Edison's and Weston's forms of dynamo. We cannot congratulate either the authors or the publishers on the issue of these unauthorised editions.

The Principles and Practice of Electric Lighting. By Alan A. Campbell Swinton. Pp. 172. (London: Longmans, Green, and Co., 1884.)

THIS is a handy and well-written account of the chief kinds of machines and lamps used in electric lighting; perhaps the best of the numerous small works lately published on the subject. It is full of information and in almost every respect up to date, though the chapter on the cost of electric lighting is already more or less put out of date by the progress of invention. The author writes impartially and agreeably. He should not call the "watt" a unit of energy.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to insure the appearance even of communications containing interesting and novel facts.*]

The Rings of Saturn

IN the interesting account of the observations of Messrs. Henry on the rings of Saturn (NATURE, May 29, p. 105) they seem to

consider the bright ring they then saw as new. On looking over my note-book I find I observed indications of such a bright ring extending inwards as far as the limb of ball. The exact words are, "I see a brighter line here," with a sketch according in position with the position of the ring shown by Messrs. Henry. The date of this observation is November 28, 1881, 11h. 35m. to 11h. 55m. I had noticed a great difference in comparing this observation with the fine sketch (given in "Instruments and Publications of the U.S. Naval Observatory, 1845–1876") by Trouvelot, made with the large telescope at Washington in 1875. In this sketch this edge, that I saw bright and that Messrs. Henry show brighter, is shown as dull and breaking up. It is true that Trouvelot saw and sketched the *other side* of the rings, but that will scarcely account for what is certainly a great difference. In the text relating to this drawing of Trouvelot's this occurs: "Of this and the succeeding figures it may in general be said that nothing is laid down which was not seen by more than one observer. The exception to this is in the case of the notches represented on the inside of the outer ring of Saturn, which were seen by M. Trouvelot with the 15-inch telescope of Harvard College Observatory, and again in Washington, and of whose existence he has no doubt."

It will be extremely interesting to know what M. Trouvelot can now see with the same instruments, as the evidence of rapid change is very strong. A. AINSLIE COMMON

June

An Experiment in Thought-Transference

THOSE of your readers who are interested in the subject of thought-transference, now being investigated, may be glad to hear of a little experiment which I recently tried here. The series of experiments was originated and carried on in this city by Mr. Malcolm Guthrie, and he has prevailed on me, on Dr. Herdman, and on one or two other more or less scientific witnesses, to be present on several occasions, to critically examine the conditions, and to impose any fresh ones that we thought desirable. I need not enter into particulars, but I will just say that the conditions under which apparent transference of thought occurs from one or more persons, steadfastly thinking, to another in the same room blindfold and wholly disconnected from the others, seem to me absolutely satisfactory, and such as to preclude the possibility of conscious collusion on the one hand or unconscious muscular indication on the other.

One evening last week after two thinkers, or agents, had been several times successful in instilling the idea of some object or drawing, at which they were looking, into the mind of the blindfold person, or percipient, I brought into the room a double opaque sheet of thick paper with a square drawn on one side and a cross or X on the other, and silently arranged it between the two agents so that each looked on one side without any notion of what was on the other. The percipient was not informed in any way that a novel modification was being made; and, as usual, there was no contact of any sort or kind, a clear space of several feet existing between each of the three people. I thought that by this variation I should decide whether either of the two agents was more active than the other; or, supposing them about equal, whether two ideas in two separate minds could be fused into one by the percipient. In a very short time the percipient made the following remarks, every one else being silent: "The thing won't keep still." "I seem to see things moving about." "First I see a thing up there, and then one down there." "I can't see either distinctly." The object was then hidden, and the percipient was told to take off the bandage and to draw the impression in her mind on a sheet of paper. She drew a square, and then said, "There was the other thing as well," and drew a cross inside the square from corner to corner, saying afterwards, "I don't know what made me put it inside."

The experiment is no more conclusive at evidence than fifty others that I have seen at Mr. Guthrie's, but it seems to me somewhat interesting that two minds should produce a disconnected sort of impression on the mind of the percipient, quite different from that which we had formerly obtained when two agents were both looking at the same thing. Once, for instance, when the object was a rude drawing of the main lines in a Union Jack, the figure was reproduced by the percipient as a whole without misgiving; except, indeed, that she expressed a doubt as to whether its middle horizontal line were present or not, and ultimately omitted it. OLIVER J. LODGE

University College, Liverpool, June 5

The Earthquake

SHORTLY after the shock of April 22 (which, by the way, was felt here and in Doughty Street by people in bed at the time) I commenced to collect evidence for the preparation of a detailed report, at first with the object of placing the materials at the disposal of any individual or Society that might be willing to take the matter up, as I felt certain that such a visitation would not be allowed to pass without attracting the attention of scientific men. It afterwards occurred to me that, as the focus of the disturbance was in East Essex, the most appropriate Society to undertake the publication of the report would be the Essex Field Club, within whose province the subject fairly comes. Having secured the assistance of one of our members, Mr. William White, I brought the matter before the meeting of the Club on April 26, and, a week later, took the opportunity of going over the districts most affected, taking notes and measurements of the angles of cracks, twists of chimneys, the positions of stopped clocks, and collecting all other information bearing upon this which is certainly the most serious earthquake that has been recorded in Britain. On this journey I was accompanied by Mr. T. V. Holmes (late of the Geological Survey) and Mr. William Cole (Hon. Sec. of the Club); Dr. Henry Laver and Mr. J. C. Shenstone, of Colchester, giving us the benefit of their local knowledge as guides. Starting from Colchester, we visited Wivenhoe, Rowhedge, East Donyland, Abberton, Peldon, West and East Mersea, Langenhoe, Fingringhoe, and the intermediate hamlets.

Hearing that my friend Mr. G. J. Symons had also been over the ground, I communicated with him, and he kindly agreed to place the whole of his materials, consisting of field-notes, maps, correspondence, and newspaper reports, at my disposal as soon as he had completed a short report which he was preparing for his *Monthly Meteorological Magazine*, and which appears in the May number of that excellent periodical. Mr. E. B. Knobel (Sec. R.A.S.), having also visited the district, has favoured me with some notes and observations, and the local press having taken the matter up on our behalf, a set of queries applying for information on the most essential points has been freely circulated throughout the county. As the result of our joint labours, I now possess a vast amount of material that requires *reducing* (both literally and in the astronomical sense), and upon which I have been engaged for the past few weeks; but as the complete discussion of all the facts will take a considerable time, I refrain for the present from expressing any views either in confirmation of or in opposition to those already put forward by your correspondents. In the meantime I will ask permission to appeal either directly or through your columns for further information from scientific observers. R. MELDOLA

21, John Street, Bedford Row, June 7

I NOTICE that in Mr. Topley's account of the earthquake in your issue of May 1 (p. 17) there is no record of its having been felt in any part of Surrey. In order that those interested may fill in further points, I send you the inclosed interesting letter I have received from Mrs. Bernard. I may also add that it was felt near Farnboro' on the South-Western line of railway.

Deepdale, Reigate, June 6 H. H. GODWIN-AUSTEN

"*Overross, Ross, Herefordshire, June* 2

"I ONLY felt it slightly, but quite decidedly. We were at Bentsbrook on the Holmwood at the time. The house is rather high, and I was sitting up in bed in an upstairs bed-room, when at about 9.30 or perhaps a little sooner, I distinctly felt the bed shake (from head to foot, I think west to east, not across) two or three times, and after a pause shake again in the same way. I had no watch to see the exact time, but I had heard the clock strike nine, and guessed it was about twenty or twenty-five minutes past. I did not see any furniture move, it was too slight for that. But I remarked on it to a servant who came up a short time after, and said I feared there had been a dynamite explosion in London. I was very much interested to see 'Earthquake in England' in the paper next morning, and to think that I had felt it so far off. Mr. Charles Chaldecott (the doctor at Dorking) told me another lady, I think in Dorking, had felt it too.

"K. M. BERNARD"

Kohlrausch's Meter-Bridge

MR. GLAZEBROOK, in commenting at the Physical Society on my use of Kohlrausch's meter-bridge with the telephone for the

measurement of the resistance of the human body, suggested that the latter instrument was too sensitive, and that from self-induction perfect silence could not be obtained. Both these remarks are true; but if time and the chairman had permitted, I should have said that absolute silence is rarely got, but that the minimum of sound is so easy, after a little practice, to estimate, that one-hundredth of a revolution on either side of it is instantly detected. The bridge wire takes ten turns on the barrel; consequently this amount is the thousandth part of a wire three metres long. Using a fixed resistance of 100$^{\omega}$, the possible error is quite unimportant, and even with 1000$^{\omega}$ it is far within other instrumental accidents.

But as in the somewhat similar case of counting "beats" between tuning-forks, a sensitive and an educated ear is needed. At first starting I found that I made considerable mistakes, one of which is recorded in a paper contributed to NATURE some weeks back. W. H. STONE

Wandsworth

Simple Methods of Measuring the Transpiration of Plants

THE "potétomètre" described in NATURE, May 22, p. 79, appears to be an ingenious but a rather complicated instrument. Experience has, however, taught me that the extremest simplicity is most desirable. Mr. Ward hints at difficulties of manipulation which are quite conceivable. The plan I have adopted, and find to answer, as far as it goes, is to insert the cut end in a small test-tube and cover the surface of the water with a little oil. The whole can then be weighed to three places of decimals, and the absolute amount of loss in a given time is easily ascertainable.

But a serious objection must be made against all experiments with cut shoots and leaves, for they can only give, at best, unsatisfactory results. The amount of transpiration varies so much under the ever-changing conditions of light, heat, dryness, &c., that it is only by a long series of comparative experiments *with the same specimen* that the differences peculiar to each kind of plant can be ascertained; and no cut shoot can be employed for two or three days, much less for several days, as are necessary for obtaining satisfactory results; as the amount of loss steadily decreases till death ensues, although the shoot may be *apparently* quite healthy for a long time. I have been experimenting for several summers on the transpiration of plants under coloured lights, and at first used cut specimens, as so many experimenters have done, but I found they were most untrustworthy. I now grow the plants in miniature pots, which are covered up in gutta-percha sheeting. These can be weighed to two places of decimals. By this simple method all difficulties are entirely obviated. GEORGE HENSLOW

Drayton House, Ealing

Worm-eating Larva

THE following note, which I received from the Rev. Robt. Dunn of Cricklade, may be worth publishing in reference to Prof. McKenny Hughes's "Notes on Earthworms." Mr. Dunn says: "This afternoon (May 6) on a gravel path I saw a worm wriggling in an unusual way, and stooping down I saw that a big earthworm had a smaller worm hanging on at the belt or knob, or whatever you call it; so I got a bit of stick and pushed off the parasite and found it no worm, but I should say a sort of centipede, with a very red head, about one inch long. So I captured him and put him in methylated spirit, when he vomited what I presume was worm's blood." He further adds that what the beast vomited was a stream of crimson fluid; it separated at once into white flocculent matter with brick-red specks, but since it has all turned into a white sediment. Mr. Dunn sent me the animal, which proves to be the larva of a beetle, either one of the Staphylinidæ or Geodephaga.[1]

Southampton W. E. DARWIN

Cultivation of Salmon Rivers

I HOPE we may assume, from the paragraph which appears among the "Notes" in your issue of last Thursday (p. 129), that the Fishery Board for Scotland is about to take some active course towards the removal of obstructions to the ascent of salmon up Scottish rivers. When you say the Board "is specially desirous to introduce as soon as possible a fishway at the falls, and this, when done, would open up some 500 miles of excellent fishing and spawning ground," I hardly think you can be alluding to any one particular river. Am I correct in supposing you refer to the aggregate mileage of rivers in Scotland now closed by *natural* obstructions, *i.e.* waterfalls? The Report of the Special Commission to inquire into the condition of the salmon fisheries of Scotland, published in 1871, informed us that the River Tay alone had some 115 miles of river blocked against the salmon by the two natural obstructions of the Tummel Falls and the Falls of Garry on the two important Tay tributaries from which the respective waterfalls are named. If your "Note" meant to include the entire mileage of Scottish rivers seriously affected by artificial dams of a more or less obstructive character (and their name is legion in Scotland), as well as by the natural barriers that occur, I think 500 miles of obstructed fishing and spawning ground is far too low an estimate; it might in fact, I should say, be multiplied at the very least by three. Now that theoretical playthings are being laid aside, and in their place appears a prospect of a more sound, natural, and scientific basis being made the foundation of our future salmon cultivation, the absolute necessity of opening up the natural breeding-beds of the fish will, it is hoped, become patent to every one, and the dream of my old friend the late William J. Ffennel, the father, so to speak, of our modern salmon fishery legislation and salmon river cultivation may at last be realised. "If I live," he said to me one day (I hardly care to remember how long ago it was, or how soon after he was taken from us), "I shall never rest until every weir and mill-dam in the three countries—England, Ireland, and Scotland—has a thoroughly good and permanent salmon ladder built upon it, or into it, or around it. We have shown we can restore the fisheries; we must now restore the rivers. That, sir, is the true position to take up, and that must be our next aim." Had Mr. Ffennel lived, river restoration would probably have progressed more than it has during the last decade. MARK HERON

June 9

[The falls referred to in our note on the Fishery Board for Scotland last week (p. 129) are the Falls of the Tummel.—ED.

[1] Mr. W. F. Blandford has called my attention to an account of a similar encounter between a worm and a larva given in Dallas's "Elements of Entomology," p. 6.

A RARE BRITISH HOLOTHURIAN

OF the six species of Holothurians with shield-shaped tentacles (the Aspidochirotæ) that are known to occur on the shores of the North Atlantic Ocean, two—*H. obscura* and *H. agglutinata*—were so shortly described by Le Sueur as to be still strange to American naturalists; no definite statement as to the presence of a true, that is, aspidochirote, Holothurian in the British seas has ever made its way into any systematic revision or synopsis of the class.

Shortly, however, after the publication of Forbes' "British Starfishes," Mr. Peach of Gorran Haven, Cornwall, published in the *Annals and Magazine of Natural History* for 1845 (vol. xv. p. 171) a short article on the "Nigger" or "Cotton-Spinner" of the Cornish fishermen, in which he quite rightly remarks that no typical Holothurian with twenty tentacles had been observed by Forbes, and exhibits a just pleasure in being able to say that he had discovered one. Later, two Irish naturalists—Prof. Kinahan and Mr. Foot—separately noted the existence of what one called *Cucumaria niger* and the other *Holothuria niger*. With an exception to be mentioned immediately, no writer has for nearly forty years given the least indication of a knowledge of the existence of this "Cotton-Spinner," and it may therefore be supposed that it was always with interest that I examined any form that came from the British seas. A short time since, on opening a Holothurian that had been in the British Museum for nearly twenty years, I found that, instead of those tubules which, arising from the wall of the cloaca, were first seen by Cuvier, and called Cuvierian organs by Johannes Müller, being small and inconspicuous, or, as often happens, altogether absent, they formed rather a large, almost solid, compact mass of

closely-packed tubes, which overlay the rectal portion of the intestine, and occupied nearly one-third of the general body-cavity.

On comparing the general structure of this animal with the account given by Mr. Peach, I found that his article dealt so little with anatomical points that it was impossible to say whether or no there was any real relation between his "Cotton-Spinner" and my specimens, which, like his, were of Cornish origin. There was, however, a physiological experiment that could be made, and which might, I hoped, be successful. In the description given by our modern master of Holothurian organisation, Semper says, in speaking of the Cuvierian organs: "The sticky property of these organs is known in the true Holothurians, and in England they have even given the name of the 'Cotton-Spinner' to *Holothuria nigra*." I attempted to draw out one of the tubes of the mass, and, as I hoped, I found it extend. I threw it into water, and I found that it swelled out. More accurate experiment showed that it could be made to elongate twelve times and to swell out in water to seven times its diameter. It was at once clear that I had before me the creature of whom Peach had written: "It is extremely irritable, and, on being touched or disturbed, throws out a bunch of white tapered threads about an inch in length and one-eighth in thickness." Peach goes on to say that they "soon become attenuated, either by the agitation of the water or the coming into contact with something;" but as he goes on to say that they stick to everything they touch, I doubt not that, when that thing is alive it tries to run away, till the moral effect of the gradually elongating and as regularly swelling threads paralyses it with fear. At Dr. Günther's suggestion I tested the strength of these elongated threads, and I found that, when so thin as to be barely visible, six were strong enough to hold up a weight of between 800 and 1000 grains.

I communicated a paper detailing the zoological and anatomical characters of this very rare form, which seems to be known only to the fishermen of Cornwall, to the Zoological Society at their meeting on May 20, and I direct attention to it in this more widely circulated journal because it seems to show in a very pointed way how from the absence of opportunity for investigating animals that live not deeper than twenty fathoms we do not only remain ignorant of the contents of our own seas, but that we have in this "Cotton-Spinner" an opportunity of testing the hypothesis of Semper as to the function of these Cuvierian organs, and of putting on the basis of scientific observation and experiment the "great detestation" in which, as Peach tells us, they are held by the fishermen. While Cuvier regarded the organs to which in later years he was made name-father as testes, and Jäger and the great majority of subsequent writers as kidneys, Semper, who had unexampled opportunities of watching and examining them in the Philippines, came to the conclusion that they were organs of offence or defence. To this conclusion the French naturalist Jourdan and the German Dr. Hamann have been led on the ground of histological observation; in England the only observations yet made have been such as are possible in a museum with specimens that have been in spirit for nearly twenty years. I earnestly hope that the line of investigation indicated by the facts that are here recorded will be soon followed out by one who is working in a marine biological laboratory on the British coast.

F. JEFFREY BELL

VISITATION OF THE ROYAL OBSERVATORY

THE visitation of the Royal Observatory, Greenwich, took place on Saturday last, when there was a very numerous attendance of astronomers and representatives of the allied sciences. The Report this year does not contain anything striking, but enables us to see how usefully and smoothly the work of the Observatory has been going on during the past year. Still novelties were not entirely absent, chief among them being the new Lassell reflector.

The new dome for this telescope was completed by Messrs. T. Cooke and Sons at the end of last March, and is in every respect satisfactory. It is thirty feet in diameter, covered with *papier-mâché*, on an iron framework, and turns with great ease. The shutter-opening extends from beyond the zenith to the horizon and is closed by a single curved shutter (3 feet 6 inches wide at the zenith and 6 feet wide at the horizon), which turns about a point in the dome-curb opposite to the shutter-opening, and runs on guiding-rails at the horizon and near the zenith, the curved shutter being continued by an open framework to complete the semicircle. This arrangement appears to leave nothing to be desired as regards ease of manipulation. After the completion of the dome, the carpenters' work on the flooring, &c., of the building and the attachment of the observing-stage (which is fixed to the dome) have necessarily occupied much time, and the building is hardly yet complete in all details. The equatorial has required a number of small repairs and general cleaning, some parts of the mounting having been probably strained in process of removal, and the bearings in particular having suffered from wear and subsequent disuse, so that it has been necessary to raise the instrument and regrind these in several instances. The mirror has been cleaned, and appears to be in very good condition as regards polish. The definition on stars seems to be very good as far as it has been practicable to test it before the mounting of the telescope has been put into proper order. The delay in the completion of the dome has necessarily delayed the work on the instrument, which is now rapidly advancing to completion.

First among the astronomical observations properly so called referred to by the Astronomer-Royal was the work done by the transit-circle. "There is no change of importance to notice in this instrument, which has been kept in good working order. A reversion-prism for use with the collimators as well as with the transit-circle is being made by Messrs. Troughton and Simms. The sun, moon, planets, and fundamental stars have been regularly observed throughout the year, together with other stars from a working catalogue of 2600 stars, comprising all stars down to the sixth magnitude inclusive which have not been observed since 1860. Considerable progress has been made in obtaining the requisite three observations of each star, and there is a good prospect that by the end of next year, when it is proposed to form a new Nine-Year Catalogue, the whole of the stars will be cleared off. The annual catalogue of stars observed in 1883 contains about 1550 stars."

The following statement shows the number of observations with the transit-circle made in the year ending 1884 May 20:—

Transits, the separate limbs being counted as separate observations	5213
Determinations of collimation error	303
Determinations of level error	360
Circle observations	5049
Determinations of nadir point (included in the number of circle-observations)...	353
Reflection-observations of stars (similarly included)	548

As regards the computations—

Clock times of transit over the true meridian, corrected for collimation, level and azimuth errors, are prepared to	1884 May 18
Clock errors and rates are determined to	May 11
Mean R.A.'s for 1884 January 1 are prepared to	May 11

In connection with this class of observation it is interesting to remark that the mean error of the moon's tabular place deduced from the meridian observations of 1883 has been brought down to + 0·03s. in right ascension and + 0″·42 in longitude. This result has arisen because in this year Prof. Newcomb's corrections to Hansen's tables have been applied in the *Nautical Almanac*, so that the comparison has reference to Hansen's theory without his empirical term of long period (intended to represent the direct action of Venus) and with an empirical alteration in the epoch of the inequality resulting from the indirect action of Venus. The mean error of Hansen's tables uncorrected was + 0·82s. in R.A. for the year 1882.

The most important reference to the spectroscopic work is the following:—

"For the determination of motions of stars in the line of sight, 412 measures have been made of the displacement of the F line in the spectra of 48 stars, 91 measures of the *b* lines in 19 stars, and two measures of the D lines in one star, besides measures of the displacements of the *b* and F lines in the spectra of the east and west limbs of Jupiter, and in the spectra of Venus and Mars, and comparisons with lines in the moon or sky spectrum made in the course of every night's observations of star-motions, or on the following morning, as a check on the adjustment of the spectroscope. Some preliminary measures have also been made of the F line in the spectrum of the Orion Nebula. The progressive change in the motion of Sirius, from recession to approach, alluded to in the last two Reports, is fully confirmed by numerous observations since last autumn, and a change of the same character is indicated in the case of Procyon. A discussion of the measures of all the stars observed here, on which I am now engaged, shows that the results of the four periods—1875 June to 1877 May, 1877 June to 1880 December, 1881 January to 1882 March 10, 1882 March 11 to 1884 March 31, in each of which the instrumental conditions were different—accord generally within the limits of the probable errors, and that there is no systematic change from recession to approach, so that the presumption against error arising from defective instrumental adjustment appears to be strong."

Passing on to another branch of the work at present undertaken by the Observatory, that connected with photographs of the sun with the view to determine the amount of spotted area, &c., we learn that two important changes have been made. First, the heliograph, which up to the present time has only given us pictures 4 inches in diameter, has been altered, as was suggested two years ago by the Solar Physics Committee, so as to take pictures of 8 inches. This necessitated a new micrometer which has already been constructed. Again, the photographs taken in India under the auspices of the Solar Physics Committee are now sent to Greenwich to be reduced with those of the previous series, and the result is a considerable increase in the number of days for which photographs are available. Thus in the year 1883 the 215 days of Greenwich are supplemented by 125 days of India, making a total of 340 out of 365 days. In 1882 we had Greenwich, 201, India 142, making up 343.

There is nothing new to remark with regard to magnetical work. We may state however that the magnetic elements for the past year were determined to be as follows:—

Approximate mean westerly declination	18° 25′.
Mean horizontal force .	3·926 (in English units). 1·810 (in metric units).
Mean dip	67° 31′ 10″ (by 9-inch needles). 67 31 36 (by 6-inch needles). 67 31 59 (by 3-inch needles).

The doings of the Deal time-ball and Westminster clock are thus referred to:—

"As regards the Deal time-ball, after various delays the arrangement, referred to in the last Report, for sending a current to Deal and receiving a return-signal through the chronopher of the Post Office telegraphs, was brought into operation on February 29, and has worked well since. The change has necessitated some slight alteration in our arrangements in order that we may be able to receive the Westminster signal through the same wire which is now used for the Deal current and its return signal. There have been 16 cases of failure in the dropping of the Deal time-ball owing to interruption of the telegraphic connections, 12 under the old system, and 4 since the new arrangement with the Post Office. On 19 days the current was weak and required the assistance of the attendant to release the trigger, and on 9 days the violence of the wind made it imprudent to raise the ball.

"The errors of the Westminster clock have been under 1s. on 53 per cent. of the days of observation, between 1s. and 2s. on 30 per cent., between 2s. and 3s. on 13 per cent., between 3s. and 4s. on 3 per cent., and between 4s. and 5s. on 1 per cent."

THE NORTH CAPE WHALE

THE North Cape or Biscay whale belongs to the group of true *Balænæ*, or smooth whales, *i.e.* those whales which have no fin on the back or furrows along the throat, as is the case with the so-called fin-whale group. It has most in common with the South Sea whale (*Balæna australis*). Its systematic name is *Balæna biscayensis* (Eschricht).

The habitat of the North Cape whale is limited to the north temperate zone of the Atlantic Ocean, whereas the Greenland whale is found most frequently in the closer vicinity of the Pole. Along the coasts of Europe the North Cape whale used to be found from the Mediterranean to the sea north of Norway, as far as the Beeren Island. Its true home, was, however, according to earlier writers who have dealt with the whale-fisheries in the preceding centuries, between Iceland and Norway, its original name—the North Cape whale—being derived from its frequent appearance around that promontory some centuries ago.

It visited the coasts of Central and South Europe regularly during the winter months, its favourite haunt appearing to be the Bay of Biscay. There it began to be pursued very early—perhaps as far back as the eleventh or twelfth century. In the fourteenth century the whale-fishery was an established industry here. It was also, according to the Icelandic Saga, "Kongespeilet," written in the twelfth century, already at that period largely caught by the Icelanders. It was called by the latter *slätbag* (smooth-back), and it was in all probability the catching of the North Cape whale of which the bard Othar of Haalogaland, *i.e.* Nordland in Norway, gave such an interesting account before King Alfred the Great of England. He stated that its haunts were then the shores of Northern Norway.

The principal expeditions for catching the whale were, however, despatched from the Bay of Biscay, but as it became more and more scarce in this part, it was followed as far as Iceland, where the Biscay fishermen found formidable rivals in the old Icelanders. It was these expeditions to Iceland which brought the Greenland whale under the notice of the southerners, and from the beginning of the seventeenth century the Greenland whale fishery around Spitzbergen became the leading industry.

In the middle of the seventeenth century the Americans began to catch whales. The Biscay whale was then very plentiful around the east coast of North America, and from the ports of "New England" numerous expeditions

for hunting this species were yearly despatched. The Americans called it "black whale," a denomination which, by the bye, also applies to other kinds.

Its range on the shores of America seems to have fallen a little south of that of Europe. It is in fact most probable that the whale visited the coast of Florida during the winter months, perhaps even more southern latitudes. Northwards it might be found as far as the sea is free from ice, but several circumstances seem to indicate that it preferred a temperate zone, and that its appearance on the shores of Greenland were merely migratory visits during the hot season. It may in fact be assumed that the North Cape whale made its regular migrations like the Greenland whale; in support of which I may point out that from the thirteenth to the fifteenth centuries the whale-hunting in the Bay of Biscay was carried on only during the winter months, and around America was limited to the season between November and April, at all events on the coast of New England.

What is known as to the principal haunts of this species of whale is alone based on the reports we possess of its hunting in the preceding centuries.

From the eighteenth century we hear no more about the catching of the North Cape whale in European waters, and in the beginning of the present century it also ceased to be hunted on the shores of America in consequence of its great scarcity.

It is therefore exceedingly interesting to find that the North Cape whale is again appearing on the east coast of America in such numbers that its catching is being resumed.

On the coasts of Europe the whale has only been discovered twice during this century, viz. in 1854, when a young one was caught at Pampeluna, the mother escaping; and in 1877, when the carcass of one—thirty-six feet in length—was cast ashore in the Bay of Toronto in Southern Italy. The skeleton of the former was brought to Copenhagen by the late Prof. Eschricht, where it now is.

The discovery which I made in 1882 on the shores of Finmarken of remains of this species of whale, hunted there by the Dutch in the sixteenth century, gave rise to further investigations as to the probable reappearance also in these parts of the North Cape whale, and from reports and circumstances brought to my knowledge, I feel convinced that considerable numbers of the North Cape whale again yearly appear on the coast of Northern Norway, where they were once so common. I must indeed regret that to ascertain with positive certainty whether this is a scientific fact is very difficult for a scientist whose stay in a certain part for scientific research is limited to a month or so. I hope, however, to obtain substantial proof of my belief at no very distant date.

For a figure of the North Cape whale I may refer the reader to that published in May 1883 in the *Bulletin* of the American Museum of Natural History, New York.

The University, Christiania G. A. GULDBERG

MEASURING EARTHQUAKES

I.—METHODS

IT is difficult to define the word earthquake in terms which will not cover cases to which the name is inappropriate. To say that an earthquake is a local disturbance of the earth's crust, propagated by the elasticity of the crust to neighbouring portions, is true, but the definition does not exclude, on the one hand, such tremors of the soil as are set up by the rumbling of a carriage, by the tread of a foot, or even by the chirp of a grasshopper, nor, on the other, those slow elastic yieldings which result from changes of atmospheric pressure, from the rise and fall of the tides, and perhaps from many other causes. One writer, in his definition of the word, limits the name earthquake to disturbances whose causes are unknown—a course open to the obvious objection that if the study of earthquakes ever advanced so far as to make the causes perfectly intelligible we should, by definition, be left with no earthquakes to study. It must be admitted, however, that in the present state of seismology this objection has no force, for in assigning an origin to any disturbance likely to be called an earthquake, we have, so far, been able to do little more than guess at possibilities. The more practicable task of determining what, at any one point within the disturbed area, the motions of the ground during an earthquake exactly are has lately received much attention, and in this department of seismology distinct progress has been made.

Apart from its scientific interest, this absolute measurement of earthquake motion is not without its practical use. Though the recent sharp earthquake in the Eastern Counties has reminded us that no part of the earth's surface can be pronounced free from liability to occasional shocks, these occur so rarely in this country that English builders are little likely to let the risk of an earthquake affect their practice. If Glasgow or Manchester had been shaken instead of Colchester, the chimneys of the

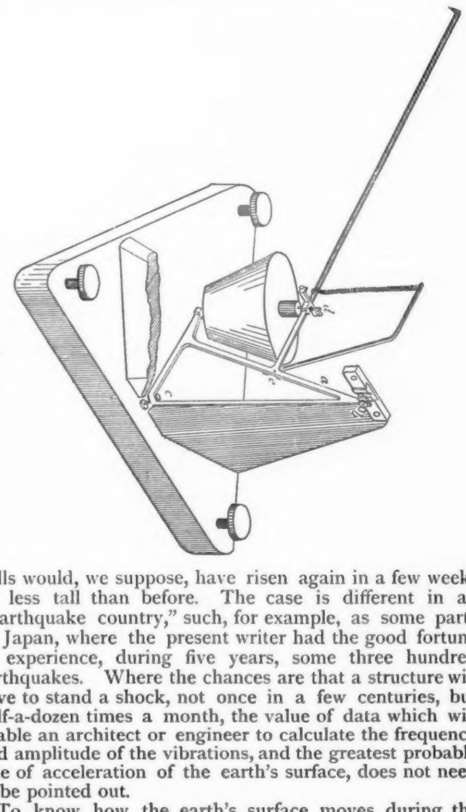

FIG. 1

mills would, we suppose, have risen again in a few weeks no less tall than before. The case is different in an "earthquake country," such, for example, as some parts of Japan, where the present writer had the good fortune to experience, during five years, some three hundred earthquakes. Where the chances are that a structure will have to stand a shock, not once in a few centuries, but half-a-dozen times a month, the value of data which will enable an architect or engineer to calculate the frequency and amplitude of the vibrations, and the greatest probable rate of acceleration of the earth's surface, does not need to be pointed out.

To know how the earth's surface moves during the passage of a disturbance we must obtain, as a standard of reference, a "steady-point," or point which will remain (at least approximately) at rest. This is a matter of no small difficulty, for (as will be shown in a second paper) the motions during any single earthquake are not only very numerous but remarkably various in direction and extent. Most early seismometers were based on the idea that an earthquake consists mainly of a single great impulse, easily distinguishable from any minor vibrations which may precede or follow it. The writer's observa-

tions of Japanese earthquakes do not bear this out. They show, on the contrary, during the passage of almost every earthquake, scores of successive movements, of which no single one is very prominently greater than the rest. Moreover, the direction in which a particle vibrates is so far from constant that it is usually impossible to specify even roughly any particular direction as that of principal movement. For these reasons attempts are futile to obtain knowledge of earthquake motions from instruments intended to show only the greatest displacement or "the direction of the shock." The indications of such instruments are, in fact, unintelligible, and it is safe to say that no seismometer is of value which does not exhibit continuously the displacement of a point from its original position during the whole course of the disturbance. The value of the observation is enormously increased if, in addition to the amount and direction of the successive displacements being shown, these are recorded in their relation to the time. We can then, besides seeing the frequency of the vibrations, calculate the greatest velocity of the motion of the surface, and also its greatest rate of acceleration—an element of chief importance in determining an earthquake's capacity for mischief, since in a rigid and rigidly founded structure the shearing force through the base is equal to the product of the acceleration into the mass, and the moment tending to cause overthrow is that product into the height of the centre of gravity.[1]

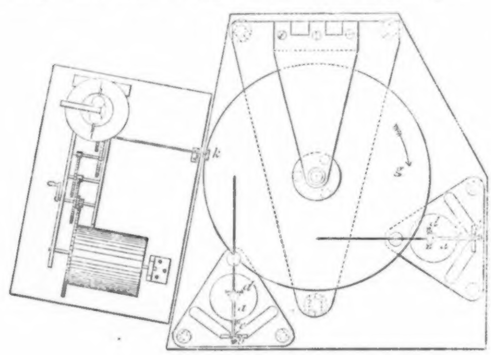

Fig. 2

Seismographs used during the last three or four years by the writer and others in Japan give a record of the earth's motion during disturbance by dividing that into three components, along the vertical and two horizontal lines. In the writer's apparatus these three are independently recorded on a revolving sheet of smoked glass, which is either maintained in uniform rotation, ready for an earthquake to begin at any moment, or is started into rotation (by help of an electro-magnetic arrangement) by the earliest tremors of the earthquake itself. The relative position of the marks on the glass serves to connect the three components with each other, and a knowledge of its speed of rotation connects them with the time. It is sufficient that the "steady-point" for each of the three components should be steady with respect to motion in one direction only. It may move with the earth in either or both of the other two directions, and in fact it is generally most convenient to provide three distinct steady-points, each with no more than one degree of freedom.

In that case each steady-point is obtained by pivoting a piece about an axis fixed to the earth, and in nearly neutral equilibrium with respect to displacements about the axis of support. When the earth's surface shakes in the direction in which the piece is free to move, the support, which is rigid, moves with it, but the centre of percussion of the pivoted piece remains approximately at rest, and so affords a point of reference with respect to which the earth's movements may be recorded. If we could get rid of friction, and if it were practicable to have the equilibrium of the pivoted piece absolutely neutral, the centre of percussion would remain (for small motions) rigorously at rest even during a prolonged disturbance. But there must be some friction at the axis of support and also at the tracer which records the relative position of a point moving with the earth and the steady-point of the seismograph. And the pivoted mass must have some small stability, to prevent a tendency to creep away from its normal position during a long continued shaking, or in consequence of changes of the vertical. If, however, the mass be so nearly astatic that its free period of oscillation is much longer than the longest period of the earthquake waves, and if great care be taken to avoid friction, the centre of percussion behaves almost exactly as a true steady-point with respect to all the most important motions of even a very insignificant earthquake. The effective inertia of the system may be further increased by pivoting a second mass on an axis passing through the centre of percussion of the first piece and parallel to the axis of support. An instrument designed on these lines in which the pivoted pieces in neutral equilibrium were

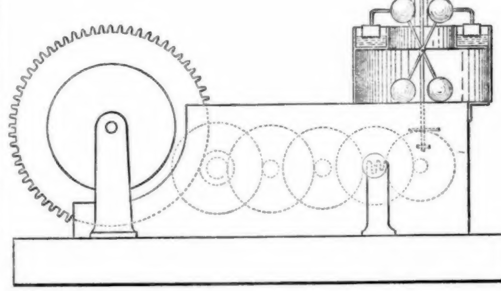

Fig. 3

two light frames supported as horizontal pendulums at right angles to each other, and with a massive bob pivoted at the centre of percussion of each, gave (in 1880) the earliest complete records of the horizontal movement of the ground during an earthquake. A description of it has been given in the *Proceedings of the Royal Society*, No. 210.

Figs. 1 and 2 show this seismograph, improved in many of its details. The form shown is one which has done excellent service in a seismological observatory which the writer was enabled to establish in the University of Tokio, through the interest of the Japanese directors. A similar instrument has also been supplied to the Government of Manila. Fig. 1 shows one of the two horizontal pendulums with a portion of one of its upright supports removed. The axis of support (which slopes very slightly forward to give a small degree of stability) is formed by two steel points, *b* and *c*, working in an agate V-groove and a conical hole. The frame of the pendulum is a light steel triangle, *a*, the effective inertia being given almost wholly by a second mass pivoted at *d* on a vertical axis which passes through the centre of percussion of the frame. The tracer, which serves to magnify as well as to record the motion, is a straw, tipped with steel, and attached to the pendulum by a horizontal joint at *d*, which allows it to accommodate itself to any inequalities in the height of the glass plate on which its distant end rests. A portion of its weight is borne by a spring, adjustable by a

[1] The case is different and much less simple where the structure is so flexible as to have a period of free vibration comparable with the periods of the earthquake vibrations.

clamp at *e*, by which the pressure of the tracer on the glass plate may be reduced to an amount just sufficient to scratch off a thin coating of lamp-black with which the glass is covered. In Fig. 2 the two pendulums are seen in plan, with their tracing pointers touching the glass plate *g* at different distances from its centre. The plate and pendulums are mounted on a single base, which is very rigidly secured to the top of a broad post, stuck firmly in the earth and projecting only a few inches above the surface. Continuous rotation is communicated to the plate by a friction-roller, *k*, held in a slot guide and connected by a universal joint to one of the arbors of a clock, which is wound up once a day. Government by an escapement being out of the question, the clock is controlled by a fluid-friction governor connected to the wheel train, also by friction gear, as shown in Fig. 3. The balls are four in number to prevent disturbance of them by an

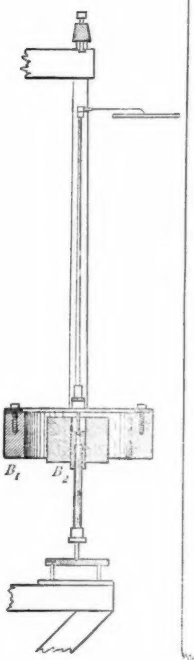

Fig. 4

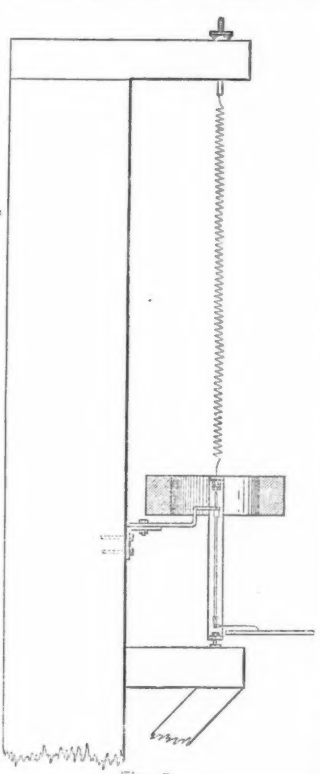

Fig. 5

earthquake. The vanes dip into oil, and are drawn back by two springs which tie them to the spindle.

When the earth shakes, the axis, *d*, of each bob remains sensibly at rest as regards components of motion perpendicular to the corresponding pendulum, and the tracing point is therefore displaced over the glass plate, in the direction of the plate's radius, through a distance which in this case is four times the motion of the earth. So long as no earthquake occurs each pointer traces over and over again a single circle on the plate. The circle frequently tends to widen inconveniently, especially if the pendulum is very nearly astatic. This is in part at least due to such changes of the vertical as have been observed by d'Abbadie, Plantamour, G. H. Darwin, and others. The plate consequently requires frequent attention, and where that cannot be given, an electric starting arrangement is to be preferred. When an earthquake has occurred, the plate is removed, varnished, and photographed by using it as a "negative."

The bob of each pendulum may of course be rigidly attached to instead of pivoted on the pendulum frame. In that case the centre of percussion of the frame and bob together (which will then be a little farther from the support than the centre of the bob) will be the steady-point. The writer, however, prefers the arrangement described above, which gives great compactness and a maximum of effective inertia, and which has the advantage of making the position of the steady-point at once determinate.

It would take too much space to describe or even to enumerate the many other devices which have been suggested to secure a steady-point by various methods of astatic support,[1] leaving one, or in some cases two, degrees of freedom to move horizontally. The horizontal

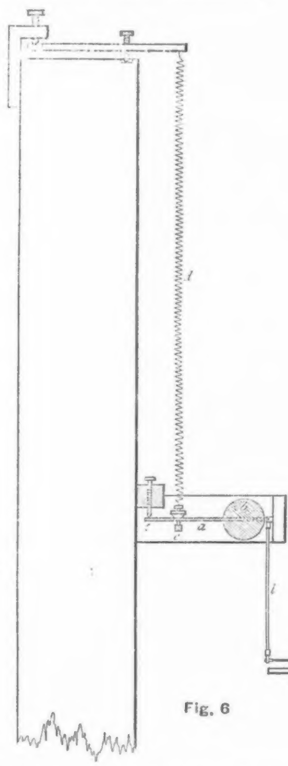

Fig. 6

pendulum has been modified by substituting a flexible wire and spring for its rigid pivots, thereby avoiding all but molecular friction at the axis of support. Spheres and cylinders, free to roll on plane or curved surfaces with or without a slab above them, have been tried, but their friction is excessive. The approximate straight-line motions of Watt and of Tchebicheff have been pressed into the service as means of suspending a mass with freedom to move in a horizontal path. The common or vertical pendulum, an old favourite with seismologists, has suffered many transformations in the effort to reduce its stability, which is preposterously great unless we make the pendulum very long. A 20-foot pendulum consisting of a cast-iron ring weighing half a hundredweight, hung

[1] See papers by Gray, Milne, the writer, and others in the *Transactions of the Seismological Society of Japan*, vols. i. to vi.; or a memoir on "Earthquake Measurement," published a year ago by the University of Tokio.

by three wires from a rigid tower, has done good work in the writer's observatory, but such an instrument has obvious drawbacks. Fig. 4 shows an arrangement, also used by the writer, and called a "duplex pendulum." A common pendulum with a ring bob, B_1, is connected to an inverted pendulum, B_2, by a ball-and-tube joint, which compels the bobs to move horizontally together. The combination can be made as nearly astatic as may be desired by proportioning the masses of the bobs to the lengths of the suspension-rods. The inverted pendulum stands on a joint which gives two freedoms to rotate but prevents twisting about a vertical axis; an extension of its rod upwards forms the multiplying arm, and carries a tracing pointer.

Another plan is shown in Fig. 5, which may be described as a duplex pendulum with a single bob, whose weight is borne partly by a socket below and partly by a spring from a support above. Any one of these instruments affords a single steady-point with respect to all motions in azimuth. Their principal use is to give "static" records of the horizontal motion, that is, records traced on *fixed* plates, which show at a glance the changes in direction of displacement during the occurrence of an earthquake.

In attempting to register the vertical component of earthquake motions, we meet with the difficulty that the weight of the mass whose inertia is to furnish a steady-point acts in the direction in which freedom of motion is to be retained. A weight hung by a spiral spring from a support above it is too stable to act as a seismometer, unless the spring be impracticably long. A horizontal bar fixed to a wall by a flexible joint and loaded at its end—an old device used by the British Association Committee at Comrie in 1842—is open to the same objection. If the loaded bar is rigid, but pivoted about a fixed horizontal axis, and held up by a spiral spring near the axis of support, we obtain a much slower period of free oscillation than if the spring were directly loaded with a weight which would stretch it to the same extent. Mr. Gray has rendered this device as nearly astatic as may be desired by adding a small tube containing mercury, whose effect is to increase the load when the bar goes down and to decrease it when the bar goes up. Another and simpler way of attaining the same result is shown in Fig. 6, which represents the vertical seismograph used in Japan by the present writer. There *a* is a horizontal bar pivoted about a horizontal axis on two points at *c*, with a heavy bob, *b*, whose weight is borne by a pair of springs, *d*. But the upward pull of the springs, instead of being applied to the bar in the line joining the axis *c* with the centre of gravity, is applied *below* that line by means of the stirrup *e*. Consequently, if the bar goes down, the pull of the springs, although increased above its normal value, is applied nearer to the axis, and (by properly adjusting the depth of *e* below the bar) the moment of the pull of the springs may thus be kept as nearly equal to the moment of the weight as may be desired—a condition which of course secures astaticism. The centre of percussion of the loaded bar is the steady-point, with respect to which the vertical motions of the ground are recorded by the multiplying lever *l* on the rim of a revolving glass plate, *o*, which may be the same plate as that which receives the record of the two horizontal components.

The instruments which have been briefly described succeed in registering very completely all the movements of the ground at an observing station during the occurrence of an ordinary earthquake, and some of them could be adapted with little difficulty to the registration of violent convulsions. It would be outside the scope of this paper to deal with the appliances by which Rossi and others have investigated those minute and almost incessant tremors of the soil whose very existence no observations less fine and careful would serve to detect.

J. A. EWING

NOTES

THE meeting for organisation of the American Association for the Advancement of Science will be held on Thursday morning, September 4; and on Friday evening, September 5, after the address of the retiring President (Prof. Charles A. Young, of the College of New Jersey), a general reception will be tendered by the citizens and ladies of Philadelphia to the members of the British and American Associations, and the ladies accompanying them. The British Association has been cordially invited, both by the American Association, to take part in their proceedings, and by the Local Committee representing citizens of Philadelphia, to accept the warm welcome which will be tendered them during the joint session. The Local Committee for the Philadelphia meeting is divided into a number of sub-committees, which have been specially created to render the stay of their visitors agreeable. It is earnestly requested that every one who intends to participate in this meeting will send his name, together with the number of ladies and gentlemen in his party, at as early a date as possible, to Dr. Persifor Frazer, Secretary of the Committee on Invitations and Receptions, 201, South Fifth Street, Philadelphia. During the week occupied by the session a number of receptions, entertainments, and excursions will be given, and a day will be set apart for the examination of the International Electrical Exhibition, to be held at Philadelphia, under the auspices of the Franklin Institute, and commencing September 2. By an arrangement between the Canadian and United States trunk lines, the members of the British Association will be furnished with first-class passage from Montreal to Philadelphia and return for 15 dollars (3*l.* 1*s.* 8*d.*), or for the single trip from Montreal to Philadelphia for 9 dollars (1*l.* 17*s.*). It is to be hoped that these rates will be further reduced before the members of the British Association will be ready to take advantage of them.

THE Executive Council of the International Health Exhibition have determined to hold an International Conference on Education in connection with the Education Division of the Exhibition: they have appointed a Committee of Management, who have drawn up a programme. For convenience of discussion all papers to be read will be printed beforehand, and they will subsequently be published by the Executive Council. Persons desirous of attending the Conference are invited to send in their names to Mr. R. Cowper, Secretary to the Committee of Management, International Health Exhibition, South Kensington, to whom any inquiries can be addressed. The following are the subjects for discussion:—1. Conditions of Healthy Education. 2. Infant Training and Teaching: (*a*) Kindergarten; (*b*) Instruction generally. 3. Technical Teaching: (*a*) Science; (*b*) Art; (*c*) Handicrafts; (*d*) Agriculture; (*e*) Domestic Economy. 4. Teaching of Music in Schools. 5. Museums, Libraries, and other Subsidiary Aids to Instruction in Connection with Schools. 6. Training of Teachers. Under this head will be considered the right professional preparation for teachers in (*a*) elementary, (*b*) intermediate and higher, (*c*) special and technical schools. 7. Inspection and Examination of Schools: (*a*) by the State; (*b*) by the Universities; (*c*) by other public bodies. 8. Organisation of Elementary Education. 9. Organisation of Intermediate and Higher Education. 10. Organisation of University Education. 11. Systems of Public Instruction in various Countries.

THE Albert Medal of the Society of Arts has been awarded by the Council of the Society, with the approval of the Prince of Wales (the President), to Capt. James Buchanan Eads, "the American engineer, whose works have been of great service in improving the water communications of North America, and have thereby rendered valuable aid to the commerce of the world."

THE death is announced of the celebrated Danish entomologist, Prof. J. C. Schiödte, at the age of sixty-nine.

THE St. Petersburg Academy of Sciences intends to publish the valuable documents which came into its possession from the great expeditions of the last century, of Krasheninnikoff, Müller, Pallas, and Messerschmidt; they are still unknown, as also the correspondence of the great explorers of Russia and Siberia.

A NEW scheme of a Polar expedition has been recently submitted by several officers of the Russian Navy to the Minister, Admiral Shestakoff. Starting from the idea that it is impossible to reach the North Pole by sea on account of the archipelagos that cover the circumpolar region, the Russian officers propose to start an expedition on sledges from the New Siberia Islands, which are 900 nautical miles distant from the Pole. This space is to be covered by sledge parties, who would make depots of provisions on the newly-discovered islands, and thus slowly but surely advance towards the north, securing at the same time the return journey of the expedition. When elaborated, the scheme will be submitted to the learned Societies, and the necessary money raised by subscriptions.

WE understand that the Commissioners under the new Universities (Scotland) Bill, if passed as it stands at present, will have power to establish, if they find it expedient, a Science Faculty in the Universities or in some of them, and to make provision for a curriculum or course of study in such Faculty which shall be coordinate with the curriculum or course of study in the Faculty of Arts. The Bill has the approval of the Senatus Academicus University of Edinburgh.

MR. JAMES JACKSON, the librarian of the Paris Geographical Society, has drawn up a useful table showing the extent to which the metrical system is used. In the following countries the system is legally obligatory:—

	Population		Population
Argentine Republic	2,830,000	Italy	28,459,451
Austria-Hungary...	37,786,346	Mexico	10,046,872
Belgium	5,520,009	Netherlands	4,172,971
Bolivia	1,957,352	Norway	1,806,900
Brazil	9,883,622	Paraguay	346,048
Chili	2,199,180	Peru	2,699,945
Colombia	4,000,000	Portugal	4,160,315
Denmark	1,969,039	Roumania...	5,073,000
Equador	946,033	Spain	16,634,345
France & Colonies	46,843,000	Sweden	4,579,115
Germany	45,234,061	Switzerland	2,846,102
Greece...	1,979,305		
			241,973,011

In the following countries the metrical system is optional:—Canada, 4,324,810; United States, 50,419,933; Great Britain and Ireland, 35,241,482; Persia, 7,653,600; total, 97,639,825. In the following countries the system is often used without its having legal value:—

	Population		Population
Egypt	6,820,000	Uruguay...	438,245
India...	198,755,993	Venezuela	2,075,245
Russia	100,372,553		
Turkey	24,804,350		333,266,386

THE Duke of Norfolk has indicated his intention of contributing 3000*l.* towards the technical department of the Firth College, Sheffield.

THE East of Scotland Naturalists' Union held a very successful meeting in Dundee on Friday and Saturday last. Dr. Buchanan White gave an instructive and interesting address; various reports were given in, papers read, and a largely-attended *conversazione* held in the evening. On the Saturday a dredging excursion was made to the Bell Rock.

THE Manchester Field Naturalists have been spending the Whitsuntide holiday in Sherwood Forest. On the way to Mansfield, which was chosen as the head-quarters of the party, a short stay was made in the mountain limestone region of Derbyshire, to examine the geology of Brick Cliff. An interesting feature of the programme was the visit made to the Creswell Caves (in a pretty ravine of the magnesian limestone) under the guidance of the Rev. J. Magens Mello, one of the principal explorers of the caves, from which, it will be remembered, important remains of the post-Pleiocene Mammalia and Neolithic instruments have been obtained. The weather was very propitious, and the visit very enjoyable.

THE seventh annual meeting and *conversazione* of the Midland Union of Natural History Societies will be held at Peterborough on Wednesday, June 25. Excursions will be made to Stibbington Hall, Bedford Purlieus, and the Decoy in Borough Fen and Croyland on Thursday, June 26. The annual meeting will be held in the Fitzwilliam Hall, Peterborough, on Wednesday, June 25, at three o'clock, the President of the Union (the Very Rev. the Dean of Peterborough) in the chair. The business of the meeting will be to receive the Report of the Council and the Treasurer's accounts; to fix the place of the next annual meeting in 1885; to award the Darwin Medal for the year 1884; to consider any suggestions that members may offer; to discuss the work of the Union during the coming year; and to transact all necessary business. The President will open the meeting with an address.

MR. F. W. EASTLAKE of Tokio informs us that the well-known Devonian Brachiopod, *Spirifer disjunctus*, in common with several other Devonian genera such as *Rhynconella*, *Cornulites*, *Spirorbis*, and the like, is called by the Chinese *shi-yên* or "Stone Swallow," and that the powdered shell is largely sold by the native druggists as a specific in urinary and renal disorders. He has obtained a specimen of the shell from South Formosa, which he regards as indicating a prolongation of that Devonian formation which, commencing with Hainan and Southern China, is traceable throughout the Loochoos and the southern provinces of Japan. *Spirifer disjunctus* is not uncommon in the Mikado's Empire, but as it is highly prized on account of its supposititious medicinal virtues, it is possible, if not probable, that the fine specimens obtained from the Japanese were originally brought from China. The very fact that *Spirifer disjunctus* is one of the ornaments of the Eastern Asiatic pharmacopœia renders it unusually difficult to trace the locality whence the Brachiopod may have been brought.

THE new Scandinavian mathematical journal, *Acta Mathematica*, has already gained such a reputation that the French Government has decided to subscribe for fifteen copies for the Facultés des Sciences. In his note to the Swedish Ambassador in Paris on this subject M. Jules Ferry points out that it is the first time his Government has supported a foreign publication, which he trusts will be an acknowledgment of the high international position the *Acta Mathematica* has gained and of the value it has become to French science. This journal is also supported by the three Scandinavian Governments.

WITH the brig *Lucinde*, which has just left Copenhagen, Lieut. Jensen of the Danish Navy, Dr. Lorentzen, and the painter Ris-Carstensen, left for Greenland for the purpose of measuring, and exploring geologically and geographically, the country between Holstensborg and Sukkertoppen, the shore of which is very broad—it is estimated about sixty miles. As this part of Greenland has never been visited by Europeans, our knowledge of its natural condition is limited. The natives state that there are deep fjords here, and great high plateaux partly covered with glaciers.

ON May 14, at 12.30 a.m., a remarkable phenomenon was observed at Nyköping in Sweden. The weather was dull and

rainy, when suddenly streamers of light were seen in the northern sky running from west to east. They were seen twice, the first time lasting about a minute, but the second very short. The light was so intense that the streets became quite light.

THE Museum of the Kendal Literary and Scientific Institution possesses a valuable series of Carboniferous fossils. Most of the zoological groups are well represented, especially in relation to Brachiopoda and Gasteropoda, the former containing large examples of *Productus giganteus*, Martin, and the latter important specimens of *Euomphalus crotolostomus*, M'Coy, and *Phanerotinus cristatus*, Sowerby. The fossils are chiefly local, many of them having been collected by the once well-known geologist of Kendal, John Ruthven, who prepared the geological map for Miss Martineau's "English Lakes." This collection has recently been named, classified, and catalogued by Mr. R. Bullen Newton, F.G.S.

IN the letter by M. Antoine d'Abbadie in NATURE for May 29 (p. 101), the passage, "it was then 24m. 8s. past midnight," should be omitted.

THE additions to the Zoological Society's Gardens during the past week include two Squirrel Monkeys (*Chrysothrix sciurea* ♂ ♀) from Brazil, presented by Mr. Robert Thom; two Black-eared Marmosets (*Hapale penicillata* ♂ ♂) from South-East Brazil, presented by Mr. C. D. Middleton; a Common Squirrel (*Sciurus vulgaris*), British, presented by Mrs. Grover; a Marsh Ichneumon (*Herpestes galera*), a Dusky Ichneumon (*Herpestes pulverulentus*) from South Africa, presented by Dr. Holub, C.M.Z.S.; two Sociable Vultures (*Vultur auricularis*) from Africa, an Angolan Vulture (*Gypohierax angolensis*) from West Africa, presented by Sir Donald Currie; a Gray Amphisbæna (*Blanus cinereus*) from Spain, presented by Mr. W. C. Tait, C.M.Z.S.; a Burchell's Zebra (*Equus burchellii* ♀) from South Africa, two Common Camels (*Camelus dromedarius*) from Egypt, five Horned Lizards (*Phrynosoma cornutum*) from North America, deposited; five Goldeneyes (*Clangula glaucion*), five Common Snakes (*Tropidonotus natrix*), twenty-four Green Lizards (*Lacerta viridis*), European, purchased; a Japanese Deer (*Cervus sika* ♀), a Mexican Deer (*Cervus mexicanus* ♀), a Long-fronted Gerbille (*Gerbillus longifrons*), born in the Gardens.

OUR ASTRONOMICAL COLUMN

THE OBSERVATORY OF PARIS.—Admiral Mouchez's report on the state of this establishment and the work accomplished therein during the past year commences with some details of his scheme for erecting a succursal observatory at a distance from Paris, where the disadvantages of location in the midst of a great city would be avoided. His proposal was to dispose of a part of the actual grounds of the Observatory, a step which would be likely to realise a sum adequate to the erection of the new building, at the same time retaining the present one to form the head-quarters of the Bureau des Calculs, the Archives, and the Museum, the two establishments to remain under the same direction and to constitute together the Observatory of Paris. This scheme, it is known, has not met with general acceptance at the hands of the scientific authorities.

M. Lœwy, in charge of the Meridian Service, has been occupied with the reobservation of stars in the Catalogue of Lalande, while a large number of observations of the sun, moon, and planets has also been made, eighteen observers taking part in this work in the course of the year. The equatorials of 12 and 14 inches aperture and the equatorial *coudé* were employed on observations of comets and small planets. The Ecliptical Charts Nos. 12, 19, 48, and 67 have progressed, and attention has been paid to double-star measures. M. Mouchez reports that the construction and installation of the great telescope (0·74 m.) has been retarded by the difficulty of establishing it in the grounds of the Observatory at Paris. In the Department of Astronomical Physics MM. Thollon and Trépied had been occupied for six weeks on the Pic du Midi, where, with M. Naussinat, in present charge of the Observatory, they studied the advantages of the station, more especially for solar observations, concluding that great scientific interest would attach to work that might be accomplished during the four or five weeks of the fine season in a small observatory at that point. Funds for the purpose are not yet available.

M. Mouchez further reports upon the distribution of time in Paris, the additions to the Museum during the year, which consist of instruments of the last century found in the Observatory of Toulouse, a portrait of Copernicus, &c.; the work of the Bureau des Calculs, which remains in charge of M. Gaillot; the publications of the Observatory during the year, including vol. xvii. of the *Annales*, in which are some important memoirs theoretical and practical; and the personal work of the staff.

A plan of the grounds of the Institution is appended, on which are distinguished those portions which M. Mouchez had proposed to alienate with the view to providing means for the erection of an observatory at a distance from Paris.

THE GREAT COMET OF 1882.—In an appendix to the Washington Observations, 1880, is an account prepared by Mr. W. C. Winlock, at the desire of the Superintendent of the Naval Observatory, Admiral Shufeldt, on the great comet of 1882 as observed at Washington, first with the 9·6 inch and subsequently with the 26-inch refractor. The latest date on which the comet's position was determined is April 4, 1883. Micrometrical measures of the nucleus were made on a number of evenings, and from a plate showing its aspect and formation between February 1 and March 3 the difficulty of deciding upon the proper point for observations of position, owing to the existence of several almost equally luminous condensations in the head of the comet, is very apparent. For a similar reason, in another plate the points observed with the transit-circle from September 19 to March 3 are shown. There has rarely, if ever, existed a greater need for precautions of this nature, to assist in the combination of the places obtained at various observatories, for the accurate determination of the orbit. The comet was first seen at Washington shortly after noon on September 19, and was visible for several hours to the naked eye about twenty-eight minutes preceding the sun and 1°·2 further south. In the 9·6-inch equatorial "it presented the appearance of a bird with wings extended," a description that applies to other comets that have been seen in daylight or in a very strongly illuminated sky, as for instance the first comet of 1847, figured in Johnston's "Atlas of Astronomy."

GEOLOGICAL NOTES

CANADIAN COALS AND LIGNITES.—Dr. G. M. Dawson collects and publishes, chiefly from the Reports of the Geological Survey of Canada, some useful Notes on the Coals and Lignites of the Canadian North-West. These mineral fuels are all of Cretaceous and Tertiary age. They are extensively developed near the Bow and Belly Rivers and their tributaries, extending eastward from the base of the mountains to about the 111th meridian; but as this is the only region yet examined in detail by the Survey, there may yet prove to be other districts of equal value. Where the Cretaceous rocks have been much disturbed and folded, the coal passes into the condition of anthracite, of which a seam occurs on the Cascade River near its confluence with the Bow River and close to the line of the Canadian Pacific Railway. Out on the plains, however, the strata are nearly flat, and as they recede from the mountains the coals show a larger percentage of water, and assume more or less completely the character of lignites.

BELGIAN ERRATICS.—To the already cited examples of fragments of Scandinavian rocks in the post-Tertiary deposits of Belgium Mr. E. van den Broeck has recently added the discovery of a piece of granite (measuring 0·8 × 0·5 × 0·6 metre) in the most northern part of the kingdom, embedded in the fine Campinian sands of Wortel—apparently the first Belgian example of any fragment large enough to claim perhaps the name of an erratic block (*Ann. Soc. Géol. du Nord.* xi. p. 2).

POSITION OF THE CALLOVIAN ROCKS.—M. Paul Choffat protests against the inclusion of the Callovian among the Upper Jurassic formations, as was decided at the last Conference of the International Commission on Geological Nomenclature. This decision, based on the palæontological affinity of the Callovian and Oxfordian stages he believes to be theoretically false and to be practically impossible of application in any general map of the whole of Europe. He gives a *résumé* of obser-

vations which in his opinion demonstrate that in the chain of the Jura, the east of the Paris basin, and in Portugal the lower part and even the whole of the Callovian are locally replaced by an extension of the Bathonian deposits.—(*Jornal de Sciencias Mathematicas*, &c., Lisboa, No. xxxvii., 1884.)

THE GLACIAL BOUNDARY IN OHIO.—Prof. G. F. Wright has for ten years past been studying the glacial phenomena of the Eastern States of the Union. Beginning with the kames of the Merrimac Valley in Eastern Massachusetts, he has followed the last edge of the glacial trail from the Atlantic border across to the southern part of Illinois. How much further he may have to trace it westwards he is at a loss to know. Meanwhile he gives an interesting outline of his labours in a pamphlet just issued by the Western Reserve Historical Society of Cleveland, Ohio. The edge of the deposits left by the ice-sheet of the Glacial Period or "terminal moraine," as the American geologists call it, has been traced by him from the western part of Pennsylvania across the southern counties of Ohio and the northern margin of Kentucky to near the Miami and Ohio Rivers. It then enters Indiana and makes a great northward sweep as far as Martinsville, a little south of Indianapolis, whence it turns south-westwards and passes into Illinois a little above the confluence of the Wabash with the Ohio. The Report gives detailed maps of the "moraine" in its passage across Ohio, with descriptions of the nature and form of the drift ridges in the different counties and townships.

HYPERSTHENE-ANDESITE AND TRICLINIC PYROXENE IN AUGITIC ROCKS.—The United States Geological Survey has begun the issue of a *Bulletin* designed to appear from time to time in single parts, each containing a single paper complete in itself. These papers are to be such as relate to the general work of the Survey, but do not properly come within the scope of the Annual Reports or Monographs. The first number is devoted to the rocks of Buffalo Peaks, Colorado. A sketch of their geology by Mr. Emmons, the geologist in charge of the Rocky Mountain Division of the Survey, is followed by a detailed description of some volcanic masses by Mr. Whitman Cross, in which he continues his interesting researches on pyroxenic rocks. As fragments among the beds of tuff and likewise in place on the shoulder of the main Buffalo Peak, there occur certain augite-andesites the microscopic study of which reveals some important peculiarities. The pyroxenic constituent shows that a rhombic mineral, probably hypersthene, is largely predominant, while a great number, if not all, of the remaining crystals must be considered as triclinic. The occurrence of triclinic pyroxene had already been detected by the author among the crystalline schists of Brittany. He has been led to re-examine many pyroxenic rocks (diabase, melaphyre, basalt, &c.) from widely separated localities, with the result of finding, in some common rocks from well-known localities, that the augite, when placed between crossed Nicol prisms, is extinguished at a very decided angle from the diagonals of the prism. This abnormal action he thinks must show either that the mineral in question is triclinic or that there is an "optical anomaly." Following the example of Fouqué, who isolated and analysed the normal augite and unsuspected hypersthene of the Santorin andesite, Mr. Cross isolated the rhombic pyroxene of the rock of Buffalo Peaks, and proved its crystalline form by examining detached crystals under the microscope. He likewise submitted it to chemical determination, which proved it to be true hypersthene. These researches induced him to test the character of the pyroxenic constituent in other andesites from all parts of the world. He has found that a rhombic pyroxene is much more abundant in porphyritic crystals than augite. He suggests the need of a reclassification of andesite rocks, of which he thinks three main groups may be distinguished. At one extreme are the varieties with a trachytic character rich in felspar, often containing quartz or tridymite, and with a more crystalline ground-mass. At the other extreme are some basalt-like masses, but with little or no olivine. The normal "augite-andesites" form the intermediate group.

KRAKATOA AND THE SUN-GLOWS

IN the last issue of the *Bulletin of the St. Petersburg Academy of Sciences* (vol. xxix. No. 2), M. Rykatcheff publishes a very interesting paper on the atmospheric waves produced by the Krakatoa eruption. General Strachey and Mr. R. H. Scott (NATURE, vol. xxix. p. 181) have already shown how the eruption must have produced an atmospheric wave which has been noticed by the barometers at many meteorological observatories. The wave was propagated in concentric circles, increasing in diameter until it reached the great circle; then, it contracted until reaching a point on the antipode of Krakatoa, whence the wave returned in the same way to its point of origin; then, gradually diminishing in intensity, it made for a second and third time its way around the earth. M. Rykatcheff now publishes the curve of the barograph of Pavlovsk for August 27 to 30, where the influence of the atmospheric wave is pretty well seen; and he discusses the results obtained from observations at thirty-one different stations (Pavlovsk, St. Petersburg, Berlin, Leipzig, Magdeburg, Brussels, Paris (I. and II.), Toulouse, Greenwich, Kew, Aberdeen, Stonyhurst, Liverpool, Glasgow, Falmouth, Armagh, Valentia, Georgia Island, Coimbra, and Toronto). It appears from these observations, when calculated according to Gen. Strachey's method, that is, by taking the time between two successive passages of the wave at the same station, that, for European stations, on the average the wave took 36h. 38m. to make its way around the earth when it was going from east to west, and 35h. 54m. when going from west to east. The accordance of the figures for different observatories is striking (excepting Tolosa), the greatest deviation from the average being only + 33m. and − 38m. in the first case, + 27m. and − 39m. in the second. The average speed would thus be: for the first wave, 303·3 metres, and 316·1 metres for the second. The calculated time of the Krakatoa eruption would be between 9h. 6m. and 9h. 42m. Krakatoa mean time; or, on the average, 9h. 23m. When the calculations are made on M. Wolf's method (which admits the same speed in both directions), the average speed of the wave is 334·3 metres, and the time of the eruption would be 10h. 39m. Krakatoa mean time. Finally, M. Rykatcheff makes the calculations by deducing both speed and time of eruption from observations made at two stations next to Krakatoa (Pavlovsk and St. Petersburg), and then he calculates from equations made for all other stations the error of the two observations. He receives thus 321·4 metres for the speed of the wave, and 10h. 16m. for the time of the eruption at Krakatoa. These results are more in accordance, he says, with the result obtained by Herr Wolf's method, and, combining both, M. Rykatcheff takes as probable 327·9 metres for the speed, and 10h. 27m. for the time of the eruption. As to the amplitudes of the oscillations of the barometers at different stations, they vary from 0·9 to 1·7 mm. and reach 2·5 mm. at Georgia Island.

To the *Meteorologische Zeitschrift* for 1884 Dr. G. Hellmann contributes a learned paper on the recent glows. No theory is advanced as to their origin, and the interest of the paper is mainly historical. The oldest reference to similar phenomena the writer has been able to discover is that of the Flemish physician, H. Brucæus, who, in 1570, dedicated a "Tractatus de Crepusculis" to Tycho Brahe. In this work occurs the passage: "Cum autem diluculum initium sumat, ubi aër splendescere incipit, idque eveniat cum lumen solis ab aëre, ob vapores permixtos crassiores, versus horizontem reflectitur, patet non in eadem distantia solis ab horizonte crepuscula semper incidere, quod non una sit semper aëris densioris sive vaporum, a quibus fieri possit radiorum reflexio, altitudo."

In the *Annales de Chimie et de Physique*, sixth series, vol. i. 1884, MM. Perrotin and Thollon deal with the same subject from the physical standpoint. They give an able *résumé* of the various accounts that have appeared, especially in NATURE, and seem on the whole disposed to accept the theory of the volcanic origin of the after-glows.

A correspondent, F. A. R. R., sends us the following communication on the subject:—

The matter projected into the upper atmosphere appears to have passed round the globe westwards with great velocity, and to have diffused itself towards north and south much less rapidly. A stratum of fine dust thus formed itself at an elevation probably exceeding the altitude of the known upper currents. This stratum caused the sun to look green or blue on the Gold Coast, in the West Indies, at the Sandwich Islands, in India and the Indian Ocean, and last, as late as September 24, in the Soudan, nearly a month after the eruption of Krakatoa. The moon and stars were frequently greenish in Europe in December and January, up to four months and a half after the eruption, and the sun whiter than usual towards setting. The finely divided matter which thus deprived the sun and moon of

part of the rays which go to form the compound white, was plainly of a different grain from the small particles commonly present in the sky, for these arrest the blue rays and scatter them, allowing the rays towards the red end of the spectrum a freer passage, so as to impress the eye with the predominant red colour of luminous objects seen through a long stretch of atmosphere. Since the declining sun in India turned strongly green, the particles competent to arrest the red rays must have exceeded, in the path of the rays, the ordinary blue-arresting particles in quantity or power. But as the sun approached close to the horizon, the lower atmosphere, by cutting off the more refrangible rays, reduced the green, and sometimes caused the red to predominate in the setting sun. The particles of a common blue haze cause the sun to set deep red. The volcanic dust particles may have exceeded in magnitude the particles which cause haze, and possibly the stratum may have contained particles which might be visible under the microscope. That this dust stratum was still present in the higher atmosphere in January was indicated by the greenish tinge of moon and stars. It was largely composed of particles of sufficient magnitude to reflect white light, for a little before sunrise the sky seemed clouded over with something resembling white cirrus haze; but like a film of dust on a mirror, or the floating dust in a room, it was not visible except at certain angles. Condensed vapour, or ice particles in a very fine state of division, would account for the persistent halo or corona of varying radius, but so also would particles of transparent pumice. Assuming the red-arresting stratum to have remained during the autumn and winter months at altitudes from forty to twenty miles, descending say 1000 feet per day during 100 days, the effects observed after sunset and before sunrise were only what might be expected to follow by reflection from the minute surfaces. In the case of ordinary cirrus, the tints up to half an hour after sunset are as follows: white, pale yellow, yellow, orange, pink, red, deep red; or the red only may be visible if the texture be thin and the early twilight strong. With a continuous red-arresting stratum, however, we must consider what influence its horizontal breadth, through which the sun's rays must pass when near setting, would have upon the light reflected from the western sky. At a height of thirty miles the sun would be shining through a great length of the stratum, as viewed from the elevated point, when it had already set on the earth immediately below. At this point, thirty miles above the earth's surface, supposing that to be the height of the stratum, the vapour of the lower air would not yet be strongly exerting its influence in arresting the blue rays, but the sheet of dust would exert its maximum power of stopping the red rays, and the light which survived best, and which from the earth's surface we should see reflected soon after sunset from above the western horizon, would be green. The stratum being so composed as to be capable of reflecting all kinds of light, but by its own action through a great breadth filtering out some of the less refrangible rays, as it did more powerfully in India when less attenuated, the reflected light of the sun above the western horizon, and indeed towards north and south as well, could not fail to be affected with an excess of green. As the sun sank still lower, viewed from the height of thirty miles, it would begin to be largely robbed of the blue and green rays by the ordinary lower atmosphere, and the next colour in the western sky would consequently be yellow, which would equally be reflected by the matter composing the stratum. The yellow would be the result of a competition between the red-arresting upper dust and the blue-arresting lower air. As the sun descended still lower, the power of the ordinary vapour-charged strata would assert itself, and the yellow would pass to orange, pink, and crimson, just as the colour of the sun seen from any eminence commonly changes in setting. The upper haze would merely reflect these naturally changing colours, but the later tints would be more striking as darkness increased. All the changes observed in the first after-glow are thus fully accounted for by larger than ordinary sky particles arresting red waves and the general mass of the stratum reflecting all rays falling upon it. The secondary after-glow would show similar gradations if the first were strong enough to emit much light, but the red in it would be most conspicuous, for the action of the lower air in eliminating blue would be more powerful than the thin veil of dust in eliminating red. There was, however, a distinct greening of the eastern sky on several occasions, signifying the approach of the secondary after-glow. The increase of apparent brilliancy of both glows as they sank westwards would of course be due to perspective.

THE FIXED STARS[1]

II.

I HAVE said that the angle between the stars is measured in terms of the scale, but the scale-value, in seconds of arc, may change by the effects of temperature and from other causes.

Bessel, in his researches on the parallax of 61 Cygni, determined by independent means the effect of temperature on his scale-value, and applied corresponding corrections to his observations. But he also took the precaution to employ two stars of comparison situated at right angles to each other with respect to the principal star, so that the effect of parallax would be at a maximum for one comparison star at the season of the year when it was at zero for the other, and *vice versâ*.

But in the course of previous researches I found that there were sources of error other than mere change of the temperature of the air, viz. differences of temperature in different parts of the instrument, and changes in the normal focus of the observer's eye, which exercised a very sensible influence on the results. It was necessary to devise some method by which these should also be eliminated.

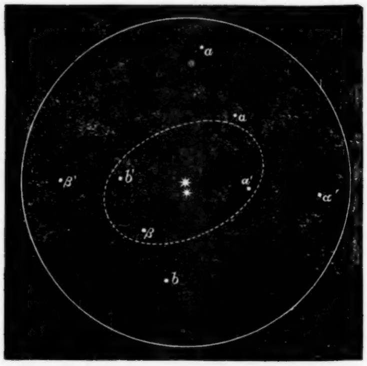

DIAGRAM II.—Showing comparison stars employed in determining the parallax of α Centauri.

There is a very simple means of doing this. Instead of taking two comparison stars at right angles, take two comparison stars situated nearly symmetrically on opposite sides of the star whose parallax is to be determined—such, for example, as the stars α and β in Diagram II. Now observe these distances in the order α, β, β, α, on each night of observation; so that on each night the observations of both distances are practically made at the same instant. Then, whatever causes have combined to create a systematic error in the measurement of one of these distances, precisely the same causes must create precisely similar systematic error in the measurement of the other distance. Thus if, by the regular or irregular effects of temperature or by changes in the normal condition of the observer's eye, we measure the distance α too great, so for the simultaneous observations of the distance β we shall from precisely the same causes measure that distance too great also.

But the *difference* of the distances will be entirely free from all errors of the kind; and, if the distances are not quite equal, it is very easy to apply a correction on the assumption that the sum of the distances is a constant.

In Diagram II. the circle represents a radius of 2° surrounding the star α Centauri. The distance of the component stars α_1 and α_2 Centauri in the diagram is enormously exaggerated for the sake of clearness. Guided by the principles just explained, search was made for comparison stars in pairs symmetrically situated with respect to α Centauri, and otherwise favourably situated for measurement of parallax.

You will remember that from the effects of parallax all stars appear to describe small ellipses about a mean position; stars near the pole of the ecliptic describing nearly circles, and those

[1] Lecture on Friday evening, May 23, at the Royal Institution, "On Recent Researches on the Distances of the Fixed Stars, and on some Future Problems in Sidereal Astronomy," by David Gill, LL.D., F.R.S., Her Majesty's Astronomer at the Cape of Good Hope. Continued from p. 137.

near the ecliptic very elongated ellipses. Obviously, then, those pairs of stars are most favourable—other conditions being equal—which lie near the major axis of the parallactic ellipse. The dotted ellipse in Diagram II. represents the form of the parallactic ellipse; that is to say, the form of the apparent path which α Centauri must describe if it is affected by parallax. Of course the size of the ellipse is exaggerated—in fact in the diagram nearly 5000 times—therefore remember that the diagram represents only that which we can compute before we have observed, viz. the *shape* of the ellipse, or the relations of the lengths of the two axes; the *absolute* size has to be determined from the observations.

The most favourable couple of comparison stars in our drawing is that marked *a* and *β*—they are nearest to the major axis of the parallactic ellipse, and they are very symmetrically situated with respect to α Centauri.

Now turn to Diagram III. Here is exhibited the results of my measures on a very large scale—in a manner similar to that in which the height of the barometer for different hours of the day, or the comparative price of wheat at different seasons of the year or in different years, is now exhibited in the daily papers. Imagine the star *a* about a mile immediately below any point of that curve, and the star *β* rather over three-quarters of of a mile immediately above the same point, and you would then have a diagram to scale.[1] The middle horizontal line represents the mean difference of these two distances, and each dot or

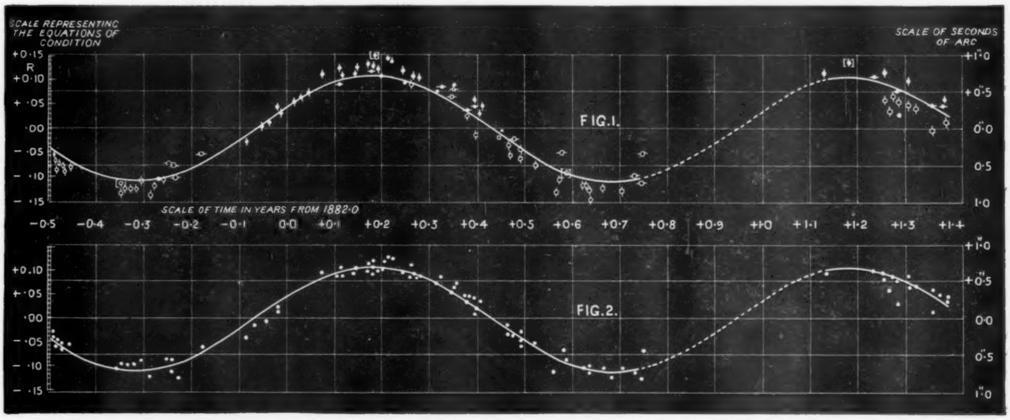

Diagram III.—Curves showing the results of the observations of α Centauri relative to the comparison stars *a* and *β*.

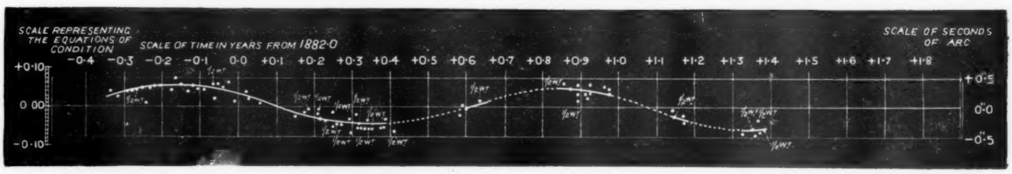

Diagram IV.—Curve showing results of observations of Sirius for parallax.

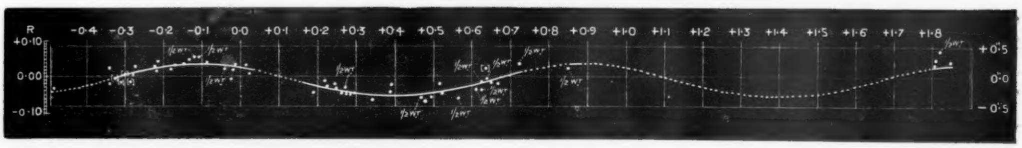

Diagram V.—Curve showing results of observations of ε Indi for parallax.

mark on Fig. 1 of the diagram represents the variation of that distance according to each successive observation. The different kinds of dot represent measures made at different hour angles, or when the relation of the direction of measurement to the line joining the observer's eye is different. These different kinds of personal errors were separately investigated, and they were then allowed for and the observations were corrected accordingly.

The observations so corrected are represented in Fig. 2, where each black dot expresses the result of the observations of a single night, and the curve is the computed curve resulting from a mathematical discussion of the observations.

You must be careful to understand that this is not simply the kind of curve which best represents the observations. The curve is limited by purely geometrical conditions to have its maximum on March 7 and its minimum on September 10, and to follow a precise form of curve according to a simple law. The observations only determine the range from maximum to minimum, and yet you see how perfectly the maximum of the observations agrees with the maximum of the curve, and the minimum of the observations with the minimum of the curve, and how closely the law is followed throughout.

The result was that from these observations the parallax of α Centauri was 0″·747, or practically three-quarters of a second of arc.

But I was not content with this result alone. I wished furthei confirmation, and selected another pair of stars, *a′* and *β′*, shown in Diagram II.

[1] In the wall diagram one second of arc was represented by about 15 inches.

From similar observations with these comparison stars I obtained for the parallax of α Centauri 0″·760, a result which is identical with the last within the limits of the probable error of either.

My friend Dr. Elkin selected the stars *a b* and *a′ b′* as his comparison stars, and in a precisely similar way he obtained as the mean of his results a parallax of 0″·752, a result identical with my own, so that we may conclude as one of the most certainly established facts of astronomy that the parallax of α Centauri relative to an average star of the seventh or eighth magnitude is three-quarters of a second of arc.

It is therefore beyond all doubt that Henderson's discovery was a real one. Herschel's verdict must therefore be confirmed, and the palm for first breaking down the barriers that separated us from any knowledge of the distances of the fixed stars be accorded to the memory of the Cape Astronomer Henderson.

So far as all existing researches go, α Centauri is the nearest of the fixed stars. Regarding the faint comparison stars as practically infinitely distant, let us try to realise how near or how far distant α Centauri really is.

There are, of course, an infinite number of illustrations which one might employ to convey some idea of such a distance. I shall content myself with one of them—something akin to which has already been used by Dr. Ball within these walls.

We are a commercial people, we like to make our estimates in pounds sterling. We shall suppose that some wealthy directors have failed in getting Parliamentary sanction to cut a sub-Atlantic tunnel to America, and so for want of some other outlet for their energy and capital they construct a railway to α Centauri. We shall neglect for the present the engineering difficulties—a mere detail—and suppose them overcome and the railway open for traffic.

We shall go further, and suppose that the directors have found the construction of such a railway to have been peculiarly easy, and that the proprietors of interstellar space had not been exorbitant in their terms for right of way. Therefore, with a view to encourage traffic, the directors had made the fares exceedingly moderate, viz. first class at one penny per 100 miles.

Desiring to take advantage of these facilities, an American gentleman, by way of providing himself with small change for the journey, buys up the National Debt of England and of a few other countries, and, presenting himself at the booking-office, demands a first-class single to α Centauri. For this he tenders in payment the scrip of the National Debt of England, which just covers the cost of his ticket; but I should explain that at this time the National Debt, from little wars coupled with some unremunerative Government investments in landed property, had run up the National Debt from 700 millions to 1100 millions sterling. Having taken his seat, it occurs to him to ask—

At what rate do you travel?

Sixty miles an hour, sir, including stoppages, is the answer.

Then when shall we reach α Centauri?

In forty-eight million six hundred and sixty-three thousand years, sir.

Humph, rather a long journey.

But enough of joking. If we wish to deal with distances so immense, we must adopt a more convenient unit of measure.

The most convenient unit for our purpose is the number of years that light would take to reach us. Light takes almost exactly 500 seconds of time to come from the sun; this is a figure easy to remember, and is probably exact to a single unit. The sun is ninety-three millions of miles distant, and this figure I believe to be exact within 200,000 miles.

Quite recently the accuracy of these figures has been confirmed in a very remarkable way by different kinds of investigations by different observers; otherwise I should not have quoted them with so much confidence.

The parallax of α Centauri is three-quarters of a second of arc; therefore its distance is 275,000 times the distance of the earth from the sun, and therefore light, which travels to the earth from the sun in 500 seconds (*i.e.* in 8⅓ minutes) would take 4·36, or a little more than 4⅓ years to come from α Centauri.

You will find in the accompanying table a specific account of the other results which were arrived at by Dr. Elkin and myself by precisely similar means, and you will find on the wall diagrams representing my own detailed observations in the case of Sirius and ε Indi.

TABLE II.—*Results of Recent Researches on the Parallax of Stars in the Southern Hemisphere*

Name of Star	Observer	Star's magnitude	Annual proper motion in arc	Parallax	Star's distance in light units, or number of years in which light from star would reach the earth	Velocity of star's motion in miles per second at right angles to line of sight
α Centauri ...	G. & E.	1	3″·67	0″·75	4·36	14·4
Sirius	G. & E.	1	1·24	0·38	8·6	9·6
Lacaille 9352	G.	7½	6·95	0·28	11·6	73
ε Indi	G. & E.	5¼	4·68	0·22	15	63
o_2 Eridani ...	G.	4½	4·10	0·17	19	69
e Eridani ...	E.	4½	3·03	0·14	23	64
ζ Tucanæ ...	E.	—	2·05	0·06	54	101
Canopus ...	E.	1	0·00	Insensible	—	—
β Centauri ...	G.	1	—	Insensible	—	—

Time does not permit me to go into more detail as to each of these separate results, full of interest though they are, and each of them representing months of labour.

My object now is to generalise, to point out the conclusions that must be drawn from these two tables of parallax (Tables I. and II.), and to see what are the broad lessons that they teach us.

A glance is sufficient to show that neither apparent magnitude nor apparent proper motion can afford a definitive criterion of the distance of any fixed star—that different stars really differ greatly in absolute brightness and in absolute motion.

And now, what is the work before us in the future?

The great cosmical problem that we have to solve is not so much what is the parallax of this or that particular star, but we have to solve the much broader questions—

1. What are the average parallaxes of stars of the *first*, *second*, *third*, and *fourth* magnitudes, compared with those of fainter magnitude?

2. What connection does there subsist between the parallax of a star and the amount and direction of its proper motion, or can it be proved that there is no such relation or connection?

With any approximate answer to these questions we should probably be able to determine the law of absorption of starlight in space, and be provided with the data at present wanting for determining with more precision the constant of precession and the amount and direction of the solar motion in space. And who can predict what hitherto unknown cosmical laws might reveal themselves in the course of such an investigation?

It is important to consider whether such a scheme of research is one that can be realised in the immediate future, or one that can only be carried to completion by the accumulated labours of successive astronomers.

I have very carefully considered this question from a practical point of view, and I have prepared a scheme, founded on the results of my past experience. I have submitted that scheme for the opinion of the most competent judges, and in their opinion, as well as my own, the work can be done, with honest hard work for one hemisphere, within ten years. I have offered to do that work for the southern hemisphere with my own hands, and a proposal for the necessary instruments and appliances is now under the consideration of my Lords Commissioners of the Admiralty. I need hardly add that in this matter I look confidently for that complete consideration and that efficient support which I have never failed to receive at their hands since I have had the honour to serve them.

The like work will be undertaken for the northern hemisphere by my friend Dr. Elkin, who is now in charge of the heliometer at Yale College in America. It is at present the finest instrument of the kind in the world, and a photograph of it you have already seen upon the screen.

I most earnestly trust that we may be granted health and strength for this work, and that no unforeseen circumstances will prevent its complete accomplishment.

Before closing this lecture I wish briefly to allude to another engine of research in sidereal astronomy which quite recently

has received an enormous development, and whose application appears to offer a rich harvest of results. I refer to the application of photography to astronomical observation.

Your respected member, Mr. De la Rue, is the father of this method. Time does not permit me to dwell on his early endeavours and his successful results, but they are well known to you all. He opened up the field, and he cleared the way for his successors.

The recent strides in the chemistry of photography and the production of dry plates of extreme sensibility have permitted the application of the method to objects that formerly could not be photographed. Here, on the screen, are the spectra of stars photographed directly from the stars by Dr. Huggins, the lines which tell of the chemical constitution and temperature of the star's atmosphere being sharply defined.

Here are photographs of the great comet of 1882, which, with the cooperation of Mr. Allis of Mowbray, I obtained at the Cape, by attaching his ordinary camera to an equatorially mounted telescope, and with its aid following the comet exactly for more than two hours. Each one of the thousands of points of light that you see is the picture of a fixed star. The photograph suggests the desirability of producing star maps by direct photography from the sky.

Here on the screen is a photograph of the great nebula of Orion, or rather a series of photographs of it made by Mr. Common of Ealing. You will note the gradual development of detail by increase of exposure, and the wonderful amount of detail at last arrived at. Here are photographs from drawings of the same, and you will note the discrepancies between them. And here is a photograph of a star cluster also by Mr. Common.

No hand of man has tampered with these pictures. They have a value on this account which gives them a distinct and separate claim to confidence above any work in which the hand of fallible man has had a part.

The standpoint of science is so different from that of art. A picture which is a mere copy of nature, in which we do not recognise somewhat of the soul of the artist, is nothing in an artistic point of view; but in a scientific point of view the more absolutely that the individuality of the artist is suppressed, and the more absolutely a rigid representation of nature is obtained, the better.

Here is a volume compiled by one of the most energetic and able of American astronomers—Prof. Holden. It contains faithful reproductions of all the available drawings that have been made by astronomers of this wonderful nebula of Orion from the year 1656 to recent times.

If now we were to suppose one hundred years to elapse, and no further observation of the nebula of Orion to be made in the interval; if in some extraordinary way all previous observations were lost, but that astronomers were offered the choice of recovering this photograph of Mr. Common's, or of losing it and preserving all the previous observations of the nebula recorded in Prof. Holden's book—how would the choice lie? I venture to say that the decision would be—Give us Mr. Common's photograph.

Is it not therefore now our duty to commence a systematic photographic record of the present aspect of the heavens? Will not coming generations expect this of us? Does not photography offer the only means by which, so far as we know, man will be able to trace out and follow some of the more slowly developing phenomena of sidereal astronomy?

Huggins has shown how the stars may be made to trace in the significant cipher of their spectra the secrets of their constitution and the story of their history. Common has shown us how the nebulæ and clusters may be separately photographed, and it is not difficult to see how that process may be applied, not only to special objects, but piece by piece to the whole sky, till we possess a photographic library of each square half-degree of the heavens. But such a work can only be accomplished by consummate instruments, and with a persistent systematic continuity which the unaided amateur is unable to procure and to employ. It is a work that must be taken up and dealt with on a national scale, on lines which Huggins and Common have so well indicated, and which has already been put in a practical form by a proposal of Norman Lockyer's at a recent meeting of the Royal Astronomical Society.

I would that I had the power to urge with due force our duty as a nation in this matter, but my powers are inadequate to the task.

I employ rather the words of Sir John Herschel, because no words of mine can equal those of him who was the prose-poet of our science, whose glowing language was always as just as it was beautiful, and whose judgment in such matters has never been excelled. They were spoken in the early days of exact sidereal astronomy, when the strongholds of space were but beginning to yield the secret of their dimensions to the untiring labour and skill of Bessel, of Struve, and of Henderson. Think what they would have been *now* when they might have told how Huggins' spectroscope had determined the kinship of the stars with our sun, how it had so far solved the mysteries of the constitution of the nebulæ, and pointed out the means of determining the absolute velocity of the celestial motions in the line of sight. Think what Herschel would have said of those photographs by Common that we have seen to-night of that nebula that Herschel himself had so laboriously studied, and whose mysterious convolutions he had in vain endeavoured adequately to portray; and think of the lessons of opportunity and of duty that he would have drawn from such discoveries, as you listen to his words spoken forty-two years ago:—

"Such results are among the fairest flowers of civilisation. They justify the vast expenditure of time and talent which have led up to them; they justify the language which men of science hold, or ought to hold, when they appeal to the Governments of their respective countries for the liberal devotion of the national means in furtherance of the great objects they propose to accomplish. They enable them not only to hold out but to redeem their promises, when they profess themselves productive labourers in a higher and richer field than that of mere material and physical advantages.

"It is then, when they become (if I may venture on such a figure without irreverence) the messengers from heaven to earth of such stupendous announcements as must strike every one who hears them with almost awful admiration, that they may claim to be listened to when they repeat in every variety of urgent instance that these are not the last of such announcements which they shall have to communicate, that there are yet behind, to search out and to declare, not only secrets of nature which shall increase the wealth or power of man, but TRUTHS which shall ennoble the age and country in which they are divulged, and, by dilating the intellect, react on the moral character of mankind. Such truths are things quite as worthy of struggles and sacrifices as many of the objects for which nations contend, and exhaust their physical and moral energies and resources. They are gems of real and durable glory in the diadems of princes, and conquests which, while they leave no tears behind them, continue for ever unalienable."

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

CAMBRIDGE.—The following are among the Readers and University Lecturers just now appointed:—Readers—Comparative Philology, Dr. Peill; Botany, Dr. Vines. University Lecturers—Comparative Philology, Mr. E. S. Roberts; Sanskrit, Mr. Neil; Mathematics, for Part 3 of the Tripos, Division A, Mr. Forsyth; Division B, Mr. Hobson; Division C, Mr. Glazebrook; Division D, Mr. J. J. Thomson; Applied Mechanics, Mr. Macaulay; Botany, Mr. F. Darwin; Animal Morphology, Mr. A. Sedgwick; Advanced Physiology, Dr. Gaskell and Mr. Lea; Histology, Mr. Langley; Geology, Mr. D. Roberts; Moral Science, Mr. Keynes.

Prof. Colvin has presented to the Fitzwilliam Museum between eight and nine hundred books on Classical Archæology, on behalf of certain members of the University, to be deposited in the library of the Museum of Classical Archæology.

A warm discussion arose on the 30th ult. in the Arts School, on the Report recommending the erection of new lecture-rooms and work-rooms for Biology and Physiology. Mr. Huddleston said the estimate of 3000*l*. a year ago had grown to 10,000*l*. now. He had hoped that finality was reached last year. Mr. Oscar Browning objected to the proposals that they were reckless and extravagant. Why not ventilate the present lecture-rooms, if they were so much used as was described? The proposal to buy 150 microscopes for 1000*l*. was one of the most ridiculous he ever heard of. Why should not each student bring his own? A science man's library was exceedingly small and inexpensive. Mr. Mayo thought sufficient accommodation might be provided by using the Museum of Zoology as a lecture-room for large classes. Mr. Sedgwick described the inconveniences felt in the late course of Elementary Biology, when 206 men had to pack

themselves where only 140 could properly sit. Many sat on the stairs, and in positions where they could not see the blackboard. Mr. Trotter urged that the medical students could not be expected to provide capital sums for buildings. The large class in Elementary Biology this year would want to attend Physiology next year. It was impossible that finality could be attained. Prof. Foster explained the serious inconveniences of requiring every student to bring his own microscope to these classes; they ought to belong to and remain in the laboratory. The difficulties that now arose had occurred because of past under-estimates. He had been laughed at a few years ago for suggesting that space for one hundred students of Physiology would be wanted soon. He had no lecture-room under his control, and no room in which he could give demonstrations to a large class, yet so important did he deem the practical work of the class in Elementary Biology that, if no new accommodation could be given to it, he should feel compelled to close the practical work of his own large class, and simply give lectures in Physiology, and give up his laboratory for the class in Elementary Biology.

SCIENTIFIC SERIALS

Journal of the Franklin Institute, No. 700, April.—Prof. Coleman Sellers, mechanics: introductory. Abstract report of a public lecture exposing various fallacies.—W. Dennis Marks, initial condensation of steam cylinders.—W. E. H. Jobbins, an investigation locating the strongest of the bronzes. The tests were made with Thurston's recording testing-machine, and gave for the two strongest bronzes the following:—Cu57, Zn42, Sn1, and Cu56, Zn42, Sn2.—J. C. Hoadley, a tilting water-meter.—S. Lloyd Wiegand, cast-iron in steam-boilers.—G. M. Bond, standards of length and their subdivision. W. Dennis Marks, economy of compound engines. Final agreement cannot be reached until "a more complete and rational set of experiments are made on the compound engine than now exist."—Dr. P. Frazer, reply to T. D. Rand's paper on the geology of Chester Valley, &c.

No. 701, May.—De Volson Wood, the most economical point of cut-off, a dialogue criticising Prof. Marks' paper.—J. P. Church, alleged remarkable error in the theory of the turbine water-wheel.—N. B. Clark, petroleum as a source of emergency power for war-ships. Proposes to employ furnaces into which petroleum is sprayed along with superheated steam and heated air.—S. L. Wiegand, cast-iron in steam-boilers.—R. Grimshaw, hanging the levers for indication.—R. Grimshaw, doctoring indicator cards.—Pliny Earle Chase, the sun-earth balance. This paper briefly expounds the author's views about harmonic relations in the solar system, and deduces values from them for the earth's mean radius of orbit, and for the weight of the sun.—G. M. Bond, standards of length and their subdivision.

Annalen der Physik und Chemie, Band xxi. No. 4, April, 1884.—G. Hansemann, on the diffusion of gases through a porous partition. The author concludes that Stefan's theory is not confirmed, but finds that the gaseous molecules within the pores offer a much greater mutual resistance than Stefan supposed.—G. Kirchhoff, on the theory of the diffusion of gases through a porous partition; a mathematical discussion of Stefan's theory.—Oskar Rother, on capillarity-measurements of salt solutions and their mixtures.—H. C. Vogel, remarks on Dr. O. Frölich's paper on the measurement of sun-temperature.—E. Warburg, on the electrolysis of solid glass. He concludes that in this obscure phenomenon the silica is not affected, and that the sodium only is moved electrically through the mass.—Emil Cohn, on the validity of Ohm's law for electrolytes.—A. Oberbeck, on electric oscillations: their magnetising action (part v.). The author concludes that undulatory currents exercise magnetising effects on iron and steel cores entirely as theory would indicate, provided account be taken of the internally induced currents.—L. Grunmach, absolute barometric measurements under a control of the vacuum by means of phenomena of electric illumination. The refusal of induction sparks to pass, or the phosphorescing of the glass surface, are chosen as indices of the exact state of the barometric vacuum.—W. Voigt, on the history of the Nobili-Guebhardt rings.

No. 5, May.—A. Winkelmann, on the diffusion of gases and vapours. This paper discusses the bearing of the formulæ of Meyer on certain changes in the coefficient of diffusion observed by Stefan's method.—L. Boltzmann, on a relation discovered by Bartoli between heat-radiation and the second law of thermodynamics.—L. Boltzmann, on the quantity of work which can be obtained in chemical combinations. An important discussion of formulæ, and bears on dissociation heat.—A. Overbeck, on electric oscillations, especially on their magnetising effect, and on the propagation of magnetic oscillations. Describes a method of experiment employing an electro-dynamometer, and concludes that the magnetic oscillations propagated along an iron rod decrease in amplitude at points successively distant from the origin of the oscillations, but that the magnitude of the decrement depends only on the quality of the iron, and is independent of its cross-section.—W. Hallwachs, on the electromotive force, the resistance, and the efficiency of secondary batteries. This paper, reprinted from the *Elektrotechnische Zeitschrift*, recounts researches by the author, and gives a summary of others by Tresca and Ayrton and Perry.—J. Stephan, on the calculation of induction-coefficients of wire coils. This paper re-discusses the formulæ used by Maxwell and by Lord Rayleigh for the cofficients of the coils used in the determination of the ohm.—J. Fröhlich, notice on the calculation of the potential of coils. This paper concludes with two convenient approximate formulæ for controlling more elaborate calculations.—S. Wleügel and S. Henrichsen, on the magnetism of organic bodies. Gives values for a number of alcohols.—J. Elster and H. Geitel, on the electricity of flame; a reply to J. Kollert.—H. Merczyng, on Fresnel's measurement of wave-length. The author contends that Fresnel never made his well-known determination with the well-known "Fresnel's mirrors," but by diffraction.—J. L. Andreæ, Boyle's law: a lecture-experiment. A thread of mercury is introduced into a long narrow vertical glass tube closed at the top, and hangs inclosing a certain volume of air permanently.—Carl Kirn, on a mercury interrupter with which the oxidation of the mercury is obviated. The contact is broken in a closed vacuous vessel.—G. Krebs, three ozone apparatus.—V. Pierre, apparatus for demonstration of the laws of elasticity of traction; apparatus for demonstration of the constitution of a longitudinal wave; galvanoscope for lecture-demonstration; apparatus for freezing water quickly under the air-pump. There is nothing very new in the first two of these. The galvanoscope is a simple modification of the vertical Bourbouze instrument. The air-pump apparatus is identical with forms often used in this country.

Bulletins de la Sociéte d'Anthropologie de Paris, tome vi., série iii., 1883.—The conclusion of M. Ujfalvy's notes on the so-called Kaffir-Giapochs of Hindoo-Koosh, based on his own observations and those of Biddulph, Elphinstone, and other English authorities.—Communications from M. Ten Kate, on the results of his anthropometric observations of the Yaquis Indians of Sonora and Arizona; from M. Errington de la Croix, on the fish-eating modern cave-dwellers of the Island of Socotra; from M. Hamy, on the dental mutilations of the modern Huaxtecs; and from M. Manouvrier, on the force of the flexible muscles of the fingers in men and women, having reference to the weight of the brain at different anatomical and physiological periods.—On the Japanese races, by M. de Quatrefages.—Reports of the Commissions appointed to examine the Cinghalese Araucarians and Kalmuks who have been brought to the Jardin d'Acclimatation for purposes of ethnographic investigation. The reports on the two latter have been drawn up by M. Deniker, whose intimate acquaintance with the language and homes of the Kalmucks gives special value to his comprehensive exposition of the ethnological and social characteristics of these people.—Recollections of Paul Broca as a student, by M. Eschenauer.—On the "Tzompantli," or sacrificial cranium, exposed in Aztek temples, by M. Hamy.—On the cranial differences observable in men and women, by M. Manouvrier, who considers that while the parietal is less developed in the latter, the occipital is generally larger in women than in men.—On the microscopical characters of the blood in the principal races, by Dr. Maurel, whose investigations do not appear to have demonstrated any very precise ethnic difference in the relations of the red and white corpuscles, unless we may accept as such his observation that the red globules of different races show different degrees of resistance to different artificial reagents.—On the use of iron in Egypt, by M. E. Soldi; and on the use of iron in China, by M. Milloué.—A *résumé*, by M. G. Hervé, of the various medical and other reports of the dimensions of Cuvier's brain. M. Hervé, basing his remarks on Dr. E. Rousseau's report of the autopsy in which the latter took part, gives the weight as 1830 grm., and the horizontal circumference as 60·45 cm. He denies that Cuvier had ever suffered from any malady capable of affect-

ing the size or condition of the brain.—On muscular anomalies of the diaphragm; suggestions for a planispheric representation of the cerebral convolutions, by M. Duval.—On the disappearance of the more fitting in the struggle for existence, by M. Delauny. The author endeavours to show that superior as well as inferior species have disappeared, leaving only the intermediate species; the inferior having succumbed to the superior, while the latter have become extinct through sterility.—On the dog of the Tertiary period in Europe, by M. Zalorowski.—On the value of the information to be deduced from ancient Egyptian paintings by the naturalist, ethnographist, and historian, by M. Piétrement.—On a supernumerary nipple with mammary glands in a young woman, by Dr. Testut.—On the origin of right-handedness in man, by Mme. Clémence Royer.—On the symmetrical character in anomalies in man, and on the influence attributable to atavism in such anomalies, by M. Verrier.—On the geographic distribution of the Opatas, Pimas, &c., with an ethnographic chart of the Basin of the Rio Grande de Santiago, by M. E. T. Hamy.

Bulletin de la Société des Naturalistes de Moscou, 1883, No. 3.—History of the hypothesis of the cosmical waves proposed for explaining the forms of the comets, by Prof. Bredichin (with two plates), being a discussion of M. Schwedoff's hypothesis on this subject; and on some apparent anomalies in the structure of the tails of the comets, by the same (both in French). Prof. Bredichin arrives at the conclusion that, more than ever, he is right in affirming that the theory of repulsive forces is enabled to explain and to predict by means of calculus, not only the whole of the phenomena afforded by the comets and their leading features, but also the slightest details of their structure.—A reply of Dr. Morawitz to General Radoszkowsky's critics with regard to the Russian species of *Bombus* (in German).—On the *Pecten exc'sus* and *pyxidatus*; note by M. Ant. de Gregorio (in French).—Monopetal plants of Dr. Radde, being a continuation, in German, of Dr. Fred. von Herder's capital description of these plants —Materials to the fauna of Russian Hemiptera, by W. Yakovleff; three new Russian species of *Odontarsus* and one *Emblethis tenellus* from Northern Persia are described (in Russian).—On the beans of *Abrus precatorius* compared with seeds of other Papilionaceæ, by Col. Tichomirow (in German), with two plates.—On the remains of *Edestus* and other fishes from the Lower Carboniferous of Moscow, by Prof. H. Trautschold (in German); the new species *Cymatodus reclinatus*, *Pœcilodus undatus*, and the new genus *Eucanthus margaritatus*, are described.—On the chief problem of higher geodesy, by Th. Sloudsky (with a plate); a mathematical discussion (in French) of the best means for determining the figure of the earth.—Letters from A. Regel from Central Asia.

Atti della R. Accademia dei Lincei, April 6.—Report on Alfonso di Legge's memoir on the length of the solar diameter, by S. Schiaparelli.—On the compressibility of fluids, and especially of water under temperatures varying from 0° to 99° C., and under pressures of from 1 to 4½ atmospheres, by Stefano Pagliani and Giuseppe Vicentini.—On the symbolic meaning of the Egyptian pyramids, by Dr. Ernesto Schiaparelli.—On the theory and classification of homographies in a linear space to any number of dimensions, by Dr. Corrado Segre.—On the equilibrium of flexible and rigid surfaces, part i., by Vito Volterra.—Remarks on the observations of the solar spots and facules made at the observatory of the Collegio Romano during the first quarter of 1884, by Pietro Tacchini.—On some transformations of orthonitroaniline and orthodiammine, by G. Koerner.—On the action of phtalic anhydride on pyrolignite, by G. L. Ciamician and M. Dennstedt.—On the molybdate of didymium, by Alfonso Cossa.—On the geological constitution of the Maritime Alps, by S. Capellini.—On some psychological difficulties which may be explained by the idea of the infinite, by Francesco Bonatelli.—Some fresh experiments with neurine, by Aliprando Moriggia.

Rendiconti del R. Istituto Lombardo, May 1.—Biographical notice of Prof. Giovanni Polli, part i., by Prof. Gaetano Strambio.—On a problem in mathematical analysis, by Prof. F. Brioschi.—Note on certain variations in the stem and blossom of *Gagea arvensis*, Schult, by Silvio Calloni.—On the struggle for existence between the *Staphylinus olens*, Müll., and the *Lumbricus agricola*, Hoffm., by the same author.—The Court of Cassation in connection with the question whether women should be admitted to the legal profession, by Prof. E. Vidari.—Meteorological observations made at the Brera Observatory, Milan, during the month of April.

Rivista Scientifico-Industriale, April 30.—On certain works required to be carried out in the Island of Ischia, in order, if possible, to prevent the disastrous consequences of future earthquakes, by Prof. Temistocle Zona.—Installation of the electric light in the railway station of Porta Nuova at Turin.—Considerations and suggestions regarding the adoption of earthenware tubes in underground telegraphs, by the engineers R. Fabri and G. A. Romano.—Obituary notice of Quintino Sella, with a list of his scientific writings, by Giuseppe Grattarola.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, May 15.—"On the Influence of Coal-dust in Colliery Explosions, No. V." By W. Galloway. Communicated by R. H. Scott, F.R.S.

At the beginning of the first paper on this subject, which I had the honour of reading before the Fellows of the Royal Society now somewhat more than eight years ago (*Proc. Roy. Soc.*, vol. xxiv. p. 354), I gave a short account of what appeared to me to be a rational mode of explaining the occurrence of all great explosions in dry and dusty collieries; and since then I have had opportunities of studying several remarkable instances of this class of phenomena, with the result that I am now more than ever satisfied with the correctness of the views which I then expressed. It is true, as some subsequent writers, among whom I may name Sir Frederick Abel, F.R.S., have observed, that coal-dust had been previously recognised as a factor in colliery explosions. I think I may safely claim, however, that no earlier author had gone the length of crediting it with the *rôle* of principal agent, and relegating fire-damp to a secondary position.

It is also admitted, I believe, by every one familiar with the subject, that my experiments with mixtures of coal-dust and air containing a small proportion of fire-damp were original. Similar experiments were subsequently made by members of the North of England Institute of Mining and Mechanical Engineers, by a committee of the Chesterfield Institute of Engineers, by Prof. Abel on behalf of the Home Office and the Royal Commission on Accidents in Mines, and by others in this country, by MM. Mallard and Le Chatelier for the Commission du Grisou in France, and by others on the Continent, all of which led to the same conclusion, namely, that air containing too small a proportion of fire-damp to render it inflammable at ordinary pressure and temperature becomes so when coal-dust is added to it. Differences of opinion were expressed as to the actual proportion of fire-damp, the comparative fineness of the coal-dust, and the quality of the coal necessary to the attainment of this result, but the general conclusion, in every case, was the one I have stated above.

In my first paper, already referred to, I had said: "If it could be shown therefore, that a mixture of air and coal-dust is inflammable at ordinary pressure and temperature, there could be no difficulty in accounting for the extent and violence of many explosions which have occurred in mines in which no large accumulations of fire-damp were known to exist," and, immediately following these words, I gave what appears to me to be a new hypothesis regarding the mode of occurrence of great colliery explosions.

My reasons for thinking it necessary to show that a mixture of air and coal-dust alone is inflammable were, first, that after some great explosions it was found that the flame had passed through very long galleries, containing presumably nothing but pure air, and of course dry coal-dust in a state of greater or less purity; and secondly, it was impossible to account for certain other explosions, except on the supposition that they had been originated by the firing of a shot in pure air in galleries containing dry coal-dust as in the last case. To have proved that a mixture of air, coal-dust, and fire-damp is inflammable did not appear to me fully to meet the case, and it was for this reason that I made further experiments with the help of a grant made to me by the Lords of Committee of Council on Education at the recommendation of this Society. The results have been described in some of the former papers of this series. In making these experiments, and in drawing certain conclusions from them, all favourable to the hypothesis referred to, I was simply carrying out the details of the work then begun, and nothing more.

In former papers I referred to several great explosions which had come under my own immediate observation. In particular I had made a very careful and complete examination of Penygraig Colliery after the explosion there in December 1880 (*Proc.*

Roy. Soc., vol. xxxii. p. 454), when I found that the flame had penetrated into every working place in the mine. The plan which accompanies No. III. paper shows that all the working places were ventilated by what was, practically, a single current of air. It was, therefore, open to those who attribute every great explosion to the occurrence of a sudden outburst of fire-damp, and, as the annals of mining show, they constituted a very large majority before the appearance of my first paper on coal-dust, to say that this explosion was due to the same cause. For this reason I have paid particular attention to the phenomena due to the explosion which occurred at Dinas Colliery on January 13, 1879. I do not propose to enter into the minute details of this case, as I should to a large extent simply be repeating what I stated about Penygraig explosion, but will confine myself to those which are necessary or new. I had frequently inspected the workings before the explosion, and I have done so at intervals of one month or less since then, so that I have been intimately acquainted with all the conditions of the mine for many years. I know also that no sudden outburst of fire-damp has ever been known to take place in it. The workings were naturally very dry, the temperature ranging from 75° to 82° F., and the floor was covered with coal-dust. Shot firing was carried on by night when the explosion happened. The damage done by the explosion was very great, the workings being wrecked to such an extent as to lead to their temporary abandonment. They were reopened after a large expenditure of time and labour, and it was only towards the end of last year that I was able to inspect one of the districts of working places, and early in the present year that I could get into the other. With the exception of some burnt hay or dried grass which I found in one of the return air-ways, I saw no traces of burning nor deposits of coked coal-dust in any of the main roadways, but I found well-marked deposits of coked coal dust in all the working places in both districts of workings as far as I was able to penetrate. The plan shows that the current of fresh air which came down the downcast shaft was split up into three separate currents. The two districts were thus ventilated quite independently of each other, and it was therefore impossible for any outburst of fire-damp which might take place in one of them to affect the quality of the air in the other.

We are thus compelled to fall back upon some other mode of explanation in this case, and I now submit that in the present, and in my previous papers, I have brought forward sufficient evidence to show that the coal-dust hypothesis is the only tenable one. If it be admitted, however, that this hypothesis is applicable to Dinas explosion, the conclusion is inevitable that, *cæteris paribus*, it is equally applicable to every case of the same kind that has ever occurred.

Zoological Society, June 3.—Prof. A. Newton, F.R.S., vice-president, in the chair.—A letter was read from Mr. Albert A. C. Le Souëf, C.M.Z.S., of the Zoological Gardens, Melbourne, giving an account of the unusual occurrence of two young ones being produced from one egg laid by a black-necked swan. The writer described the appearance of these cygnets, which were much smaller than a companion bird of the same age.—Mr. F. E. Beddard read a paper upon the visceral anatomy of *Hapalemur griseus*, and called attention to the various points of difference between this species and *Hapalemur simus*.—Mr. A. D. Bartlett read a paper on some singular hybrids of bovine animals bred in the Society's Gardens.—Mr. G. E. Dobson, F.R.S., read a paper on the unimportance of the presence or absence of the hallux as a generic character in Mammalia, as evidenced by the gradual disappearance of this digit within the limits of a single genus (*Erinaceus*).—A communication was read from Mr. H. W. Bates, containing a list of the Coleoptera of the families Carabidæ and Scarabæidæ collected by the late Mr. W. A. Forbes on the Lower Niger. Of these three appeared to be previously undescribed.—Dr. Carl Lumholtz read a paper containing notes upon some mammals which he had recently discovered in Queensland.

Anthropological Institute, May 13.—Prof. Flower, F.R.S., president, in the chair.—Dr. Maxwell T. Masters exhibited a series of agricultural implements brought by Mr. Livesay from the Naga Hills, at the north-east corner of Assam. The tools were chiefly such as are used for rice culture on the irrigated slopes of the hills, and consisted of rakes made of bamboo and wood, a hoe and iron knife with wooden sheath and cord for suspension.—Dr. J. Stephens sent a drawing of a large pointed palæolithic implement recently found near Reading, length 9¼ inches, weight 2 lbs. 3¼ oz.—Mr. W. G. Smith exhibited two palæolithic implements recently found in North London. One was made of quartzite, and is the first example of this material met with in the London gravels; the other was a white implement from the "trail and warp." He also exhibited two white porcellaneous palæolithic flakes replaced on to their original blocks; the four pieces were found by him in North London, wide distances apart, at different times during the last six years.—Mr. Smith also exhibited a large axe from New Guinea with a keen blade of siliceous schist or banded chert, 9⅝ inches long, and weighing over 2¼ lbs. The axe was sent home by a sailor, and Mr. Smith purchased it of a person who was using it in North London for chopping up firewood.—A paper on the ethnology of the Andaman Islands, by Mr. E. H. Man was read.—Prof. Flower read some additional observations on the osteology of the natives of the Andaman Islands. Since reading a paper before the Institute on the same subject in 1879, the author had had the opportunity of examining ten additional skeletons, two of which are in the Museum of the University of Oxford, and eight in the Barnard Davis Collection now in the Museum of the Royal College of Surgeons. Five are males and five females, and all are adult. The measurements of these specimens have thoroughly established the fact that the twelve skulls of each sex previously examined furnished a very fair average of the characters of the race.

CAMBRIDGE

Philosophical Society, April 28.—Mr. Glaisher, president, in the chair.—The following communications were made to the Society:—By Mr. R. T. Glazebrook, on the electro-magnetic theory of light.—By Mr. A. H. Leahy, on the pulsation of spheres in an elastic medium. The problem of two pulsating spheres in an incompressible fluid has been discussed by several writers. The author considers the analogous problem in the case in which the medium surrounding the spheres has the properties of an elastic solid. He finds that the most important term in the expression of the law of force between the two spheres varies inversely as the square of the distance between them. This force will be an attraction if the spheres be in unlike phases, a repulsion if they be in like phases at any instant. The next term in the expression varies inversely as the cube of the distance between the two spheres, and is always a repulsion.

EDINBURGH

Royal Society, June 2.—Sheriff Forbes Irvine in the chair.—Prof. Tait communicated a paper by the Rev. T. P. Kirkman on the enumeration, description, and construction of knots. The paper described the application of a particular set of the polyhedra investigated by the author to the investigation of the subject.—Prof. Tait then read the second part of a former paper of his own on knots. He first considered the modification required to be made on Mr. Kirkman's diagrams so that they might represent actual knots. He also took up the question of the identity of some of the figures with the view of determining the actual number of different knots having a given number of crossings. Finally he recurred to the problem of beknottedness, showing how it was to be determined in any case upon the consideration that *locking* may occur with two strings, and even with one, as well as with three.—Mr. John Aitken read a second note on the recent sunsets, showing how all the phenomena observed received a satisfactory explanation on the hypothesis that they resulted from the presence of abnormal quantities of dust particles in the air. He pointed out that the facts considered adverse to this conclusion really furnished additional proof.—Mr. Aitken then read a paper on thermometer screens, which gave rise to an animated discussion.

DUBLIN

Royal Society, May 19.—Section of Physical and Experimental Science.—G. F. Fitzgerald, F.R.S., in the chair.—On the pitch-curves of cogged wheels, by A. H. Curtis, LL.D. The author showed that a pitch-curve A, *of any form*, its axis a, and also the axis b of the corresponding pitch-curve B, being given, the curve B must be such that, if it roll without sliding on A (the initial point of contact c being of points which in working would come together), carrying b with it, the roulette thus described by b will be a circle having a for centre; hence he deduced the known result that the point of contact of the pitch-curves must be situated on $a\,b$—for the tangent at b to the roulette must be perpendicular to $b\,c$, while, as this roulette is a circle, this tangent must also be perpendicular to $a\,b$; he proved that, if $p = \phi(r)$ be the equation of A, $p' = \frac{r'}{\kappa - r'}\,\phi(\kappa - r')$,

where κ = length *a b*, will be the equation of *B*. He mentioned also that Prof. Willis had proved that *all* working teeth on corresponding pitch-curves are roulettes of the same curve and generated by the same point, and also that, with circular pitch-curves, teeth which were involutes of circles concentric respectively with the corresponding pitch-curves, and having the same centre of similitude with them, would work correctly, and stated that these theorems taken together had suggested to him the question, What curve rolling on a circle will generate, and by what point, the involute of a concentric circle? This curve he proved to be an equilateral spiral whose pole is the generating point.—On the alleged effect of magnetism on the human body, by Prof. W. F. Barrett. In a recent address Sir W. Thomson drew attention to the "marvellous fact" that a powerful magnetic field appeared to exert no action on the human body, and stated his conviction that, "if there is not a distinct magnetic sense, it is a very great wonder that there is not." The object of the present paper was to describe certain facts which had come under the author's observation, and which pointed in the direction of a distinct sensory and therapeutic effect produced by a powerful electro-magnet upon certain individuals. A careful examination of upwards of 100 persons had led to the discovery of three individuals who could instantly detect by their sensations when the current was put on or taken off a large electro-magnet, between the poles of which their heads had been placed. In an absolutely darkened room a singular luminous glare was also seen over the magnetic poles by these three observers. Every care was taken to avoid collusion or chance coincidence, and the observers had no means of knowing by any other means when the current was put "on" or "off." If a distinct magnetic sense exist, as these experiments seem to suggest, it is doubtless rare and fitful, depending possibly on the state of the percipient's health. The author then described experiments that had been made by Charcot in Paris, Dr. W. H. Stone at St. Thomas's Hospital, London, and Prof. Dreschfeld at the Manchester Infirmary, to ascertain the pathological effect of a powerful magnet. The two former authorities had noticed the transference of sensation produced by magnetism in patients suffering from hysteria or hemi-anæsthesia, under conditions which appeared to preclude the possibility of imagination coming into play. Dr. Dreschfeld describes three cases which came under his own observation where anæsthesia was cured by a large electro-magnet. In one case, particulars of which were published in the *British Medical Journal*, every care was taken to eliminate causes other than the specific effect of magnetism, and there seemed no doubt that the patient's complete restoration to health was due to the latter cause alone. In conclusion Prof. Barrett remarked that should the therapeutic value of magnetism in certain specific disorders be established, it would obviously give no support to certain magnetic appliances which are sold as nostrums for all diseases, and of the specific value of which he was not aware that there exists the smallest medical evidence.—On the substitution of sodium bichromate for the potassium salt in bichromate batteries, by Prof. W. F. Barrett. Prof. Barrett stated that a week or two ago Mr. Moss placed in his hands a specimen of bichromate of soda, and asked him to try whether it would efficiently replace the potash salt which is invariably employed in bichromate cells. The result of his examination showed that there was no appreciable difference between the electromotive force, the internal resistance, and the constancy of the two cells, charged with equal weights of the soda and of the potash salt respectively.—Reply to the criticisms of M. Lœwy, by Howard Grubb, F.R.S. (see NATURE for May 29, p. 100).

Section of Natural Science.—V. Ball, F.R.S., in the chair.—On the origin of freshwater faunæ, a study in evolution, by Prof. W. J. Sollas, D.Sc., F.G.S. The poverty of freshwater faunæ as compared with marine is commonly attributed to a supposed inadaptability on the part of marine organisms to existence in fresh water. That this explanation is inadequate is shown by the existence of freshwater jelly-fish such as *Limnocodium*, and still more directly by the experiments of Beudant, who succeeded in accustoming several kinds of marine mollusca to a freshwater habitat. The view of Von Martens that the severity of a freshwater climate is prohibitive of the existence of most marine forms in rivers is insufficient, and a more thoroughgoing explanation is necessary. This is to be found in a study of the means by which the distribution of marine animals is secured. In the case of stationary forms free-swimming embryos are distributed over wide areas by currents, and they can never pass from the sea into rivers, in which the current is always directed seawards. Nor, probably, could an attached form once introduced into a river permanently establish itself so long as its propagation took place exclusively through free-swimming larvæ, for these would gradually be borne out to sea. Hence, freshwater animals should not, as a rule, pass through a free larval stage of existence, nor, as a matter of fact, do they. In Hydra, freshwater sponges, and Polyzoa, the young usually emerge from a horny cyst in the complete state. In the Unionidæ, the glochidium s age provides for distribution without involving a seaward journey. The young of freshwater mollusks do not enter upon a free existence till they are similar to their parents, and Paludina is viviparous. The suppression of a free-swimming larval stage not only occurs in freshwater but in many marine invertebrates. This is connected with the fact that the larval stage is in a position of disadvantage as compared with the adult. Hence there is an advantage to the organism if the larval stage can be passed over in a state of seclusion. From this various other modifications follow; development in seclusion involves a supply of accessible food, hence the appearance of yelk and other kinds of nourishment furnished by the parent to the imprisoned embryo. Again, the secluded larva being spared the drudgery of working for its own existence, and supplied with nutriment in a form that puts the least tax on its digestive powers, a larger balance of energy remains available for metamorphic changes. Thus arise the phenomena of accelerated and abbreviated development. Further, the shortening of the larval life probably leads to the lengthening of the adult life, and shifts the chances of variation and selection forward into the adult stage. Thus animals which hatch out in a complete state will most probably suffer modifications of that state, and not of previous ones, except very indirectly. Here we discover a direct tendency towards a mode of development which explains the "arborescent" character of our zoological classifications, *i.e.* the tendency of the tree of life is now to produce leaves rather than new branches. In the case of freshwater fauna very direct reasons have existed for the suppression of the free larval stage. In this connection may be noticed the richness in species and the poverty in genera of the freshwater mollusca. In discussing the origin of freshwater faunæ there are three hypotheses from which we have to select: (1) that marine forms have migrated into rivers; (2) that they have migrated into marshes and thence into rivers; and (3) that marine areas have been converted into freshwater ones. The last course has been the most usual, especially in the case of non-locomotive forms. Hence the origin of freshwater invertebrates is connected with the great movements which have affected the earth's crust. The earliest well-known lacustrine areas are those of the Old Red Sandstone, in one of which we meet with the earliest known freshwater mollusk, *Anodonta jukesii* (Forbes). The lakes of the Permo-Triassic period contributed additions to the freshwater fauna of the globe. The *Neritidæ* and *Cerithiadæ* are probably post-Palæozoic families, and, as the *Neritinæ* and *Melaniidæ* are so closely connected with them, they may be regarded as their collateral or direct descendants, and thus may have originated in Triassic lakes, but not earlier. Other genera probably arose at the same time; the occurrence in Cretaceous deposits of *Unio*, *Physa*, *Valvata*, and *Lymnea* in the Nearctic, Palæarctic, and Oriental regions, suggests a high antiquity for these genera; and they may have existed in Palæozoic times. The lakes of the Tertiary period furnished probably further contributions to our freshwater fauna, such as *Lithoglyphus* and *Dreissena*. Thus, existing freshwater genera are probably descended from marine forms which became metamorphosed in the waters of the Devonian, Triassic, and Tertiary lakes. In the lakes of Central Africa the Tertiary freshwater fauna still survives, nearly all of the genera from Lake Tanganyika being referable to genera already in existence in Mesozoic and Tertiary times. The lakes of the Northern Hemisphere received on subsiding beneath the glacial sea such Arctic forms as *Mysis relicta* and *Pontoporeia affinis*, but most of their existing inhabitants have re-entered them since their emergence from the sea.

PARIS

Academy of Sciences, May 26.—M. Rolland, president, in the chair.—Observations of the small planets made with the great meridian instrument of the Paris Observatory during the first three months of the year 1884; communicated by M. Mouchez. The observations of January 11, February 11 and 12, March 14 and 15, were made by M. P. Puiseux, all the rest by M. H. Renan.—Remarks on the sense of sight in its relations with different colours placed in juxtaposition, by M. Chevreul.—Fresh experiments made with a view to determine the locality

and mode of formation of urea in the animal system, by MM. Gréhant and Quinquaud. From these experiments, which consisted mainly in making a quantitative analysis of the urea in the blood flowing to and from a given organ, the authors infer that the abdominal viscera are the seat of a continuous formation of urea.—Experimental studies on the anæsthetic properties of the chloruretted derivatives of formine, by MM. J. Regnauld and Villejean.—On the theory of quaternions: a demonstration of Sylvester's proposition that the theory of quaternions is identical with the theory of binary matrices, by M. Ed. Weyr.—On the circulation of the liquid mass of the sun, by M. P. Lamey. Assuming as a postulate the total fluidity of the solar mass, the author endeavours to show that, in virtue of the continuous cooling of the surface layer, the whole volume must be in constant circulation, and that the circuit thence resulting may be represented by a simple geometrical figure, which has several points at a tangent with the surface of the solar globe.—Note on the electric conductivity of the liquid and solid anhydrous salts, by M. Foussereau.—On the gaseous tensions of liquid amalgams, by M. Isambert.—Thermic studies of the alkaline fluosilicates: three methods of obtaining fluosilicates of potassa, soda, and lithia, by M. Ch. Truchot.—Fresh researches on bromuretted carbolic acids—their melting heat, specific heat, and heat of neutralisation, by M. E. Werner.—On some reactions of albumen, by M. E. Grimaux.—Analytical study of the chief mineral fertilisers contained in arable lands, by M. G. Lechartier.—Note on the alluvial and lacustrine formations of the basin of the Shott Melrirh, Eastern Sahara, by M. G. Rolland.—On the transformations of a parasitic Peridinian (*Gymnodinium pulvisculus*, Bergh.), by M. G. Pouchet.—A contribution to the study of the virulent principle in puerperal septicæmia, by M. S. Arloing.—On a new method of transfusion of blood previously subjected to the action of peptone, by M. Afanassiew.—On the exaggerated statements regarding the intensity of atmospheric evaporation during the spring equinox, with comparative readings of the evaporometer during the years 1873–1884, by M. L. Descroix.

June 2.—M. Rolland, president, in the chair.—Arithmetical commentary on the theorem discussed by Gauss in his "Disquisitiones," § 357, by M. de Jonquières.—Note on the theory of the winding-gear employed in extracting ores from deep mines, by M. Haton de la Goupillière.—On the mean reciprocal distances of the planets in the primordial state of the solar system; letter addressed to M. Hermite by M. Hugo Gyldén. The respective mean distances, supposed to be far less absolutely than at present, are determined as under:—Mercury, 0·443; Venus, 0·519; Earth, 0·562; Mars, 0·625; Jupiter, 0·850; Saturn, 0·988; Uranus, 1·177; Neptune, 1·322.—Explanation of a method of determining the temperature of the parts of the sun below the photosphere, by M. Hirn.—Fermentation of saccharine juices; experimental researches on the influence of the pneumatic treatment by a current of purified air at the ordinary temperature, or heated to 65° C., by M. P. Calliburcès.—Suggestions for constructing a mercurial galvanometer (hydrostatic galvanometer), by M. J. Carpentier. The paper refers to experiments made as early as January 1881, and are here reproduced as having preceded the apparatus of a similar character submitted to the Academy by M. Lippmann on May 19, 1884.—On the reaction of fused gold and silver in the vapour of phosphorus, by MM. P. Hautefeuille and A. Perrey.—On the action of the sulphuret of mercury on the sulphuret of potassium, by M. A. Ditte.—Note on the combination of chlorides of gold with chlorides of phosphorus by M. L. Lindet.—On the anatomy and nervous system of the Australasian Gasteropod, *Parmophorus australis* (*Scutus*), by M. Boutan.—Contributions to the natural history of the Haliotides, by M. H. Wegmann. The author, who had previously submitted a study of their nervous system, here completes the subject by a full anatomical description of these animals.—Account of the freshwater *Lithoderma fontanum*, Nob., a species of brown Alga (Melanophyceæ) from Montpellier, by M. Ch. Flahault.—On a new genus of vegetable fossils discovered by M. Fayol in the coal-mines of Commentry, by MM. B. Renault and R. Zeiller. The authors, who, from their discoverer, propose the generic name of Fayolia for these plants, give full-size illustrations of two species, *F. dentata* and *F. grandis*.—On some new types of rocks from the volcanic Mount Dore (Clermont), with a description of the successive formations in that district, by M. A. Michel Lévy.—Hydrology of the Ohio Basin, in connection with the recent disastrous inundations in that region, with map, by MM. Fr. Mahan and G. Lemoine.—On the pseudo-meningitis (pseudo-meningitis otopiesis) observed in young deaf-and-dumb subjects, by M. Boucheron.

VIENNA

Imperial Academy of Sciences, May 8.—R. Latzel, on the Myriopoda of the Austro-Hungarian Empire (containing the description of Symphyleæ, Ponropoda, Diplopoda).—K. Deschmann, on the tumuli of Rovisce in the parish of Bründl in Lower Carniola.—L. Boltzmann, on the possibility of basing a kinetic theory of gases on attractive forces alone.—P. Czermak, on the value of some integrals of Maxwell's theory of gases based on a certain law of forces.—F. Zehden, method for calculating a true moon distance by an observed one.—E. Zuckerkandl, on the apparatus of circulation in the nasal mucous membrane.—F. Rimmer, experiments on nutations and directions of growth of seed-plants.—T. Habermann, on diethylalizarin-ether.—F. Fiala, on some mixed ethers of hydroquinone.

May 15.—A. Rollett, contribution to a knowledge of the process of contraction in striated muscles.—F. Kolacek, on a method for determining the electric conductivity of liquids.—A. G. Nathorit, remarks on Herr von Ettingshausen's essay, "On the Tertiary Flora of Japan."—C. Langer, on the origin of the internal jugular vein.—D. Lersch, notes on comets.—E. von Hœrdtl, contributions to Assyrian chronology.

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